POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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The Turbine Operating Floor at Michigan City Station.

Photo by Korling.

Performance *Par Excellence*

WHAT WOULD YOU say if somebody told you of a station which had a turbine operating factor of over 95 per cent, a load factor of over 70 per cent, an operating record which hits within one per cent of bogey and a lot of other seemingly impossible attainments? You'd look at him rather critically, wouldn't you? And if you knew him well enough to be impolite you would exclaim sarcastically, "Some station! There ain't no such animal."

Well there is, and to prove it we present the above photograph—a view of the turbine operating floor of this station as the crane operator sees it. Now a crane operator's viewpoint may be attractive, indeed, as you can see, it is unusually attractive in this instance but it is of little value in substantiating the performance claims we have been making. Engineers are more interested in the plant operator's viewpoint.

So, to please engineers who demand more than merely an artistic photograph, we present on page 796 a complete performance record of this station since it went into operation in January, 1931, indeed, we are mighty glad to have the opportunity, for after reading it you will agree with us that it is a record of performance, *par excellence.*

It may be, however, that you are not interested in steam plants; your interest may be in hydraulics. In that case, the article on the Eagle Pass Hydraulic turbine tests on page 821 will be more to your liking. Here again we have unusual performance—turbine efficiencies of 93.9 per cent, overall efficiencies of 90.7 per cent, efficiencies which challenge comparison. The Eagle Pass station, you may recall, was described in detail in our August 1st issue. This sequel completes the picture.

How much noise does a Diesel engine make? This was the question which confronted the operators of a plant in Iowa recently when people living in the neighborhood complained that the noise of the engines constituted a nuisance and brought the matter into court. Well, they had instruments in the plant for measuring everything from soup to kilowatts but nothing to measure noise. So they used their heads and went to the local telephone company who came to the rescue with a noise meter and a frequency analyzer. What they did with it and how they ran the noise to its lair is a dramatic narrative well worthy of a place in the annals of Scotland Yard. John Drabelle is the author of this unusual detective story on page 826.

WITH THE EDITORS

Oxygenitis

OF ALL THE DISEASES to which the power plant is heir, there is none more prevalent and difficult to master than "oxygenitis"—oxygen out of control. Furnaces and boiler settings afflicted with oxygenitis have had their days in the hospitals and clinics and the doctors are now in position to prescribe remedies for any outbreak of the disease in this section of the power plant anatomy. In most cases where the disease attacks exterior surfaces, properly compounded cosmetics are recommended by the doctors as the most effective treatment for the prevention of the spread of the disease. Internal oxygenitis, however, is not so easily detected; it may develop rapidly into a disaster and the remedies suggested are by no means infallible.

Corrosion in the water and steam lines of power plants is generally attributed to the presence of oxygen and the use of deaerating equipment has alleviated many of the former corrosion troubles, particularly in piping. In condensers, condensate piping, boilers and turbines, however, the problem is still aggravating and dangerous and the complete solution is in the offing.

In boilers, for example, many engineers have experienced corrosion difficulties coincident with the elimination of scale, which led, in some instances, to the practice of actually treating return condensate to a dose of scale-forming ingredients on its way to the boiler. Today, however, this practice does not meet with general favor as it is believed the elimination of oxygen is the correct solution. Nevertheless, corrosion does occur in boilers where extreme care is taken to eliminate oxygen. The location of the affected parts varies with the boiler design, feedwater discharge arrangement, boiler water circulation, rate of evaporation, blowdown practice and any other condition which is likely to change the evaporating conditions within the boiler. Thus it has been observed that identical boilers in a battery show sysmptoms of corrosion at entirely different parts of the interior.

Another vulnerable point of attack for this disease is the steam turbine blades. Combined with the erosive action of condensate, oxidation of the metal blades presents a problem that is extremely baffling and a satisfactory solution is still being sought.

Even the condenser, which functions in many instances as a deaerator, has points that are subject to attacks of corrosion. Engineers in charge of plant operation are studying carefully all phases of operating conditions that are likely to result in high oxygen content in the water and steam system. Sufficient work has been done along this line to indicate that no plant is entirely immune to the disease and, like cancer, oxygenitis is prevalent among the aged. With combined thought and collection of data, progress in the control of oxygen is inevitable; in the meantime engineers will do well to make frequent and careful inspection of equipment subject to corrosion and keep the oxygen content of the feedwater down to the minimum possible.

Possibilities

OPINIONS have been expressed by a number of engineers that, in generation of power we are nearing the limit of economic progress along present lines; that some new and revolutionary process, whose effect will be comparable to the introduction of steam power into industry, must be evolved or discovered, if we are to better present performance to any great extent.

Survey of present knowledge reveals no such process as probably under incubation, hence it would seem that hope for advance lies largely in perfecting of details, better coördination of facilities and improvement in methods of distribution and utilization.

In his address to the British Association, President Miles Walker argued that in distribution of power and products of industry is to be found the crudest link of our social structure, citing the spread between generating and manufacturing costs and the prices paid by ultimate consumers.

Replacement of muscular effort by mechanical power is the basis for most of our material progress since the middle ages. Because with past limits to power transmission, it was simpler to concentrate workers than to distribute power widely, big centers of manufacture and trade have grown up, bringing difficult problems in housing, government and social adjustment. Unemployment and relief of the unemployed are much more difficult problems in large cities than in small communities.

Because of this, pessimism has grown up in some quarters as to the benefit of scientific and material progress to humanity but consideration of conditions in the least progressive countries such as India and interior Africa and comparison of the lives of the majority of their inhabitants and the spread between most fortunate and least fortunate there with the conditions in advanced countries seems the best answer to the pessimists.

It must be admitted, however, that conditions in the most progressive countries leave much to be desired. From present experience, it would appear that wider availability of power, leading to deconcentration of industry is likely to make for better living conditions, better industrial organization and less difficult problems of government.

In this connection, development of the mercury-vapor arc is likely to play an important part. Use is made of a grid which, when made negative, allows no current to flow but made positive allows passage of current. By connecting two grids to an alternating-current source, alternating current can be delivered from a direct-current source. This makes possible transmission of current at direct-current voltage of 180,000 more easily than at alternating-current voltage of 130,000 and blocks out difficulties due to capacity and inductive action. One frequency may be changed to another, so that 3-phase currents at any frequency may be drawn from a single-phase line.

Development of this method may have important results in widening the availability of power and spreading industry over larger territory, thus reducing population density in congested areas.

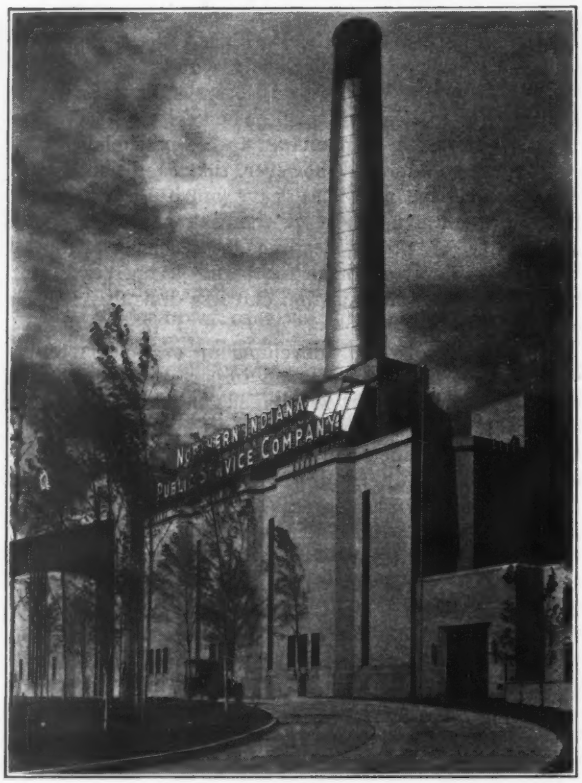
POWER PLANT ENGINEERING December 1932

"MICHIGAN CITY" — A Design and Operating R

A Station in Which Good Design and Good Operation Combine to Make It a Credit to the System and an Asset to the Community. Turbine Operation Factor 95.6 Per Cent; Load Factor Over 70 Per Cent; Operation 98.9 Per Cent of Bogey; 0.35 Per Cent Makeup; No Boiler Water Treatment; 3½ Mo. Experience with Petroleum Coke Are Some of the Features Which Make This Station Outsanding and Interesting.

FATE AND HUMAN LIMITATIONS combine to make it difficult for a power station to fulfill all expectations of the designers, hopes of the operators and aesthetics of city planning commissions. In these respects, by good fortune, the Michigan City Generating Station of the Northern Indiana Public Service Company occupies a position which is perhaps unique in power history.

This station is modern—650 lb., 750 deg. F., direct fired pulverized fuel, water wells, slag tap furnaces and four stages of extraction heating—yet it is a conservative modernism, embodying the cumulative design experience of half a dozen stations in the same area. Confidence reposed in the design and construction was such that steam was not on the turbine until the throttle was turned at the formal opening of the station on Jan. 12, 1931.



Since that time the station has operated at an average load factor of over 70 per cent and, which is more remarkable, operating performance since opening has been within 1 per cent of the design figures. This in spite of the fact that for many months after starting, the automatic coal sampler was giving samples running around 275 B.t.u. per lb. of coal higher than the actual value and that pieces of chipped nozzle blocks lodged in the high-pressure blading and increased the water rate of the turbine until found during inspection.

Design values as calculated from the guarantees in the fall of 1929, over a year before the station was started, are shown by the curve, Fig. 1. Agreement between the calculated curve and actual operating results is remarkable down to 30,000 kw. Below this point the curve flattens out and actual performance is considerably better than expected.

Although steam was not turned on the turbine prior to the formal opening of the station, load was picked up and carried immediately. No extended "tuning up" was needed nor were major equipment changes or replacements made. That only minor difficulties were encountered is shown by the fact that the turbine operation factor for the first year was 95.6 per cent and the average boiler availability factor was 72.46 per cent. Some of these minor adjustments will be mentioned in more detail later. Fundamentally this satisfactory performance is the result of proper load planning and station design although the importance of operation cannot be overemphasized.

Nor are the architectural and landscape features of the station subordinated. The station is at the harbor mouth opposite the city park in the most prominent location in the city. No attempt has been made to disguise the plant as a Gothic cathedral. The building is of light colored brick of the modern type of power plant architecture with long vertical panels. The breaker

A Station With An Unique Record

The 64,000 Kw. Turbo-Generator at Michigan City Station.

house and belt conveyor, usually an unsightly part of any plant, have been enclosed and arched so that they add to rather than detract from the appearance of the station.

The beauty of the plant and setting is apparent from the photographs and one cannot look along the harbor toward the station and well landscaped grounds without feeling that the station adds to the beauty of the city as well as being a distinct financial asset.

Building Capacity Two Units

At present a single 64,000-kw. (net) 1800-r.p.m. unit is installed in a building large enough to install three more boilers and another generating unit. As shown by the small scale property plat, Fig. 4, future additions to the station can be extended northward toward the lake with the proposed dock line as the limit. The area to the north of the present plant is now being filled in by the granulated slag from the furnaces. Circulating water facilities from the harbor will take care of a proposed ultimate capacity of 1,000,000 kw., which is not as fantastic as it sounds at first because this southern stretch of the lake, the Workshop of America, is capable of unlimited industrial growth.

The turbine is a 68,000-kw. unit driving a 70,600-kv.a., 0.906 p.f., 3-phase, 60-cycle, 22,000-v. main generator, a 5714-kv.a., 0.70 p.f., 3-phase, 60-cycle, 2,300-v. auxilary shaft generator and two 250-v. d.c. exciters, a 350-kw. unit for the main generator and a 70-kw. unit for the auxiliary generator. No atmospheric exhaust piping from the condenser is installed, the turbine being equipped with an automatic stop which trips the turbine when the vacuum drops to 17 in. This stop is visible at the right of the turbine picture shown opposite the editorial page of this issue. The condenser and exhaust end of the turbine are protected against pressure in excess of 5 lb. ga. by two lead bursting plates on top of the turbine. The steam jet vacuum pumps are placed on the operating floor and can be seen at the left-hand side of the turbine picture. Four stages of extraction heating are employed, the final full load feedwater temperature being in the neighborhood of 400 deg. F., as shown by the heat balance diagram, Fig. 2. Makeup is evaporated, the evaporator condenser being between the A and B heaters. Water flow to or from the hot water reservoir or surge tank depends upon load changes and is under the control of floats in the hotwell.

Under the turbine, and set crosswise, is a 50,000 sq. ft. horizontal, single pass condenser with a deaerating hotwell designed for a steam condensing capacity of 550,000 lb. per hr. with 70 deg. F. water. Two vertical circulating pumps with a capacity of 42,500 g.p.m. each against a 14 ft. head are installed in the screen house at the east end of the plant.

Circulating water is taken from the harbor and pumped through a tunnel under the boiler room through the condenser and discharged to the lake on the opposite side of the plant, short circuiting of the water back to

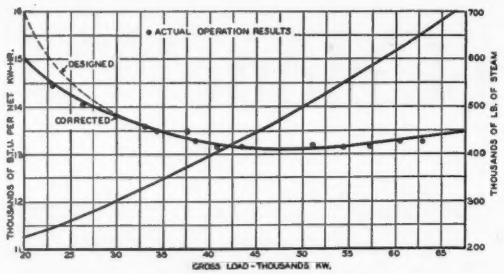


FIG. 1. DESIGNED AND ACTUAL PLANT PERFORMANCE CURVE FOR MICHIGAN CITY STATION

the harbor being prevented by a U. S. government pier 1800 ft. long.

It was not felt necessary to provide recirculation of circulating water due to the tortuous channel pack ice would have to follow, and the combination of winds which could send any considerable quantity of ice up the channel. Should experience show that an ice melting line is necessary a connection is made to the discharge tunnel which can be piped up to the intake and in this way bring some of the warm discharge water back; at present this is blanked off.

Boiler Room

Each of the three 7917 sq. ft. cross drum boilers has a steaming capacity of 345,000 lb. per hr. and is designed for a pressure of 800 lb. Operating conditions at the superheater outlet are 680 lb. ga., 770 deg. F. and at the turbine throttle 650 lb. ga., 750 deg. F. One boiler will carry the load up to about 33,000 kw. and two units will carry maximum turbine load leaving one free at all times.

As shown by the cross-sectional drawing, Fig. 5, boilers are equipped with 5072 sq. ft. interdeck convection superheaters, 14,929 sq. ft. steel economizers and 42,000 sq. ft. tubular air heaters. Furnaces have a volume of 14,700 cu. ft. (heat release 31,800 B.t.u. per cu. ft.) and 2250 sq. ft. of water cooled side wall surface. They are of the slag tap type bottom, No. 1 air cooled and Nos. 2 and 3 water cooled. Boilers No. 1 and 2 have two ball mills and eight burners per unit while boiler No. 3 has two table mills and 4 burners, the capacity of all mills being 12.5 t. per hr.

One 96,000 c.f.m. forced draft fan and one 178,000 c.f.m. induced draft fan are installed for each of the three units. Both fans on No. 1 boiler have two squirrel cage motors (high and low speed) but the fans on the other two boilers have but one squirrel cage motor each but with space, foundations and fan shaft extensions, made so that a second low speed motor can be added later if necessary. Recognizing necessity for protecting the surrounding territory from possible dust emitted by the pulverized coal furnaces, electrostatic precipitators were installed to remove from 92 to 98 per cent of the dust from the flue gas. These can be seen in the photograph at the base of the stack.

Electrical design is based on a station with an ultimate capacity of approximately 1,000,000-kw. generating at 22 kv. 3 phase, 60 cycle. All power transformers and main switching equipment are located out of doors. Output of the first two units will be transmitted at 132 kv. through the existing outdoor station on the property known as the Hoosier Slide. Each generator will be operated with its own transformer bank as a unit.

To handle this power a temporary 22 kv. switchyard of the open type has been established with stub busses connecting directly to transformers located at the Hoosier Slide Substation. The 22-kv. stub bus is merely for the convenient handling of the station auxiliary power. All 22-kv. switching equipment has a rating of 37 kv. to permit its use elsewhere on the N. I. P. S. Co. 33-kv. system when the temporary 22-kv. switchyard is abandoned.

At the time Unit No. 3 is installed it is proposed to establish a 22-kv. metal clad switchyard parallel to the operating building. All transformers have been purchased with 22-kv. pothead connections with the idea of fitting in the metal clad switching scheme as well as obtaining the safety features which accompany pothead connections.

The operating building is arranged to handle four units without extensive changes. The ultimate plan will, no doubt, justify developing a new operating building that will be more centrally located with respect to the extended turbine room. The steel switchboard panels installed with Unit No. 1 lend themselves to rearrangement of the operating building with minimum changes.

Auxiliary switch rooms have been located between the turbine room and boiler room in order to reduce the length of cable runs. One switch room is located in a sub-basement and the other at the fan floor elevation, as shown by Fig. 6 with the bulk of the auxiliary switching equipment installed in the sub-basement switch room to facilitate handling cables. This location permits feeding the majority of the motors from below instead of from overhead. It is the only location that could be assured for the continuous development of the station without going to a larger size building. The lower space between the turbine room and boiler No. 3 that exists for Unit No. 1 will be gradually taken over by larger boilers as the station develops.

Auxiliary Power System

Auxiliary power at 2300-v. is normally supplied from the 4000-kw. direct-connected auxiliary generator and a 6000-kv.a., 3-phase auxiliary transformer connected to the 22-kv. generator stub bus. A 6000-kv.a. reserve auxiliary transformer may be used to replace either the auxiliary generator or normal auxiliary transformer by means of a transfer bus, as shown by Fig. 7.

The house generator and auxiliary transformer each

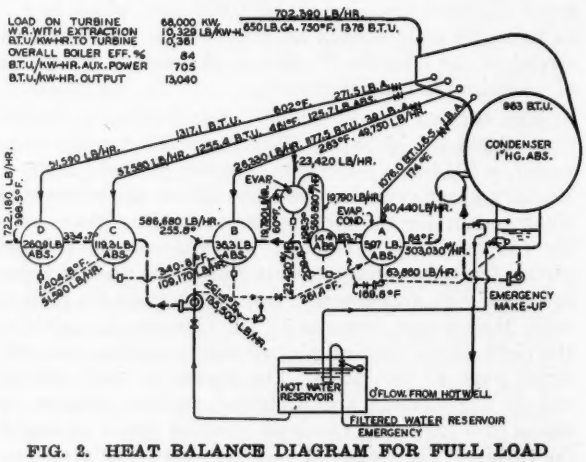


FIG. 2. HEAT BALANCE DIAGRAM FOR FULL LOAD

feed a separate 2300-v. bus group of metal clad oil circuit breakers to which are connected the various 2300-v. motors and smaller transformers. In general, half of the auxiliaries are connected to the auxiliary generator bus and half to the auxiliary transformer bus. Wherever there is any duplication, such as circulating pumps and feedwater pumps, one is fed from the auxiliary generator bus and the other from the auxiliary transformer bus. Likewise, all the auxiliaries for half a boiler are fed from one bus and the other half from the other bus.

Auxiliary power at 440-v. for the main building is supplied from two 750-kv-a. 3-phase transformers which feed two main groups of air circuit breakers. One transformer is connected to the auxiliary generator bus and the other to the auxiliary transformer bus. A 440-v. transfer bus and reserve auxiliary transformer duplicates the 2300-v. bus scheme. The larger 440-v. motors are controlled directly from the two main groups and the balance are controlled from sub-groups fed from the main groups.

Switchboards

All switchboards are ⅛ in. steel. The generator and feeder switchboards are each of the closed benchboard type with hinged rear doors for mounting relays and meters. There are two groups of 90-in. steel cubicles switchboard for the control of the various auxiliary sources of power supply. All switchboards were completely wired at the factory and in the case of the benchboards, equipped with hinged terminal boards which drop down into the cable pit thereby relieving the congestion usually found at the bottom of switchboard panels. The main and auxiliary generators are equipped with exciter rheostatic voltage regulators. As a further aid in maintaining voltage during the full voltage starting of large motors the auxiliary generator exciter is specially designed for quick response excitation.

The main generator is Y connected with a neutral brought out for differential relay protection. The neutral is grounded through an 8-ohm outdoor type oil immersed iron core reactor. A reactor was selected in place of a resistor because of the smaller size and lower

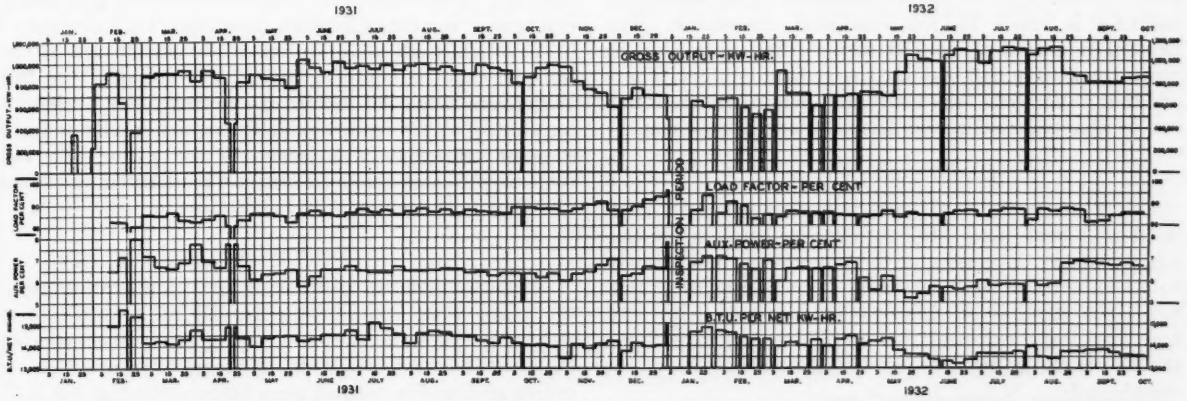


FIG. 3. SINCE STARTING, THE STATION HAS BEEN WELLLOADED, WITH LITTLE OUTAGE AND OPERATING AT 98.9 PER CENT BOGEY. THE PERFORMANCE CURVES ARE DAILY AVERAGES BY WEEKS

Auxiliary power (440-v.) for the coal handling system is supplied by a main and a reserve 750-kv-a., 3-phase transformer from a bus which may be connected to either the 2300-v. auxiliary generator bus or auxiliary transformer bus through oil circuit breakers. The oil circuit breakers feeding the 2300-kv. coal handling substation are interlocked to prevent paralleling the auxiliary generator and auxiliary transformer, except through the auxiliary generator and auxiliary transformer oil circuit breakers.

A lighting transformer bus, to which the station lighting transformers and yard lighting circuits are connected, may be fed from either the auxiliary generator bus or auxiliary transformer bus through interlocked oil circuit breakers in the same manner as the coal handling substation. D.C. for control and power is supplied from two 120-cell, 250-v. plate storage batteries, each having an 8-hour rate of 80 amperes and one-hour rate of 320 amperes with a final voltage of 1.75 v. per cell. A middle tap is brought out for 125/250-v. service such as emergency lights. Loop feeds supply all of the important control busses, such as the outdoor switchyards and auxiliary power groups. In the majority of cases, the control for switching equipment is fed radially from the group control busses.

cost. A reactor is more effective than a resistor of the same ohmic value in limiting short circuit current because its inductive reactance adds directly to the generator reactance whereas resistance adds at right angles to the generator reactance. The auxiliary generator is also Y connected with the neutral brought out for differential relay protection but not grounded because it is not considered desirable to have the 2300-v. auxiliary power system grounded.

Auxiliary Generator

The auxiliary generator is displaced electrically with respect to the main generator to compensate for the 30 deg. displacement of the 2300-v. side of the 6000-kv-a. auxiliary transformers fed from the 22-kv. bus. This permits paralleling the house generator with the auxiliary transformers for brief intervals in transferring load. Normally the house generator is not paralleled with the main generator through the auxiliary transformer because of circulating currents, the magnitude of which depends upon the load on the main and auxiliary generators. Minimum circulating current occurs when the main generator is carrying approximately 25,000-kw. It is not necessary from a mechanical standpoint to adjust the load on these generators for

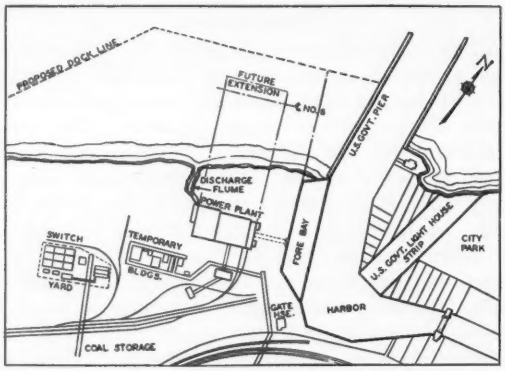


FIG. 4. PROPERTY PLAT SHOWING THE HARBOR INTAKE AND AREA FOR EXPANSION

paralleling because the coupling is strong enough to parallel with any combination of rated loads.

Main bank of power transformers consists of three 25,000-kv.a., single-phase, 60-cycle, Inertaire water-cooled units and one spare. The primary winding is rated 22-kv. and is delta connected. The secondary winding is rated 138-kv. and is Y connected. The neutral is insulated for 73 kv. so that a resistor or reactor can be added to limit the ground current. There are four 3 per cent taps above and below 138 kv. which can be changed under load from the operating room.

Cable Connections

Main generator leads are varnished cambric insulated with braid and asbestos covering between the terminal leads at the generator to the potheads immediately below on turbine room basement floor. From these potheads the cable is oil filled paper insulated with lead and duck tape covering to the 132-kv. switchyard via the switching equipment at the 22-kv. bus in 22-kv. switchyard.

The power cables between main generator and power transformers, and between auxiliary transformer and 22-kv. oil circuit breakers are equipped with pressure type oil reservoirs mounted adjacent to the potheads at generator foundation 22-kv. switchyard oil circuit breakers, power and auxiliary transformers, except on the cables at main generator oil circuit breaker where gravity feed reservoirs are provided. The reservoirs on the transformers are of the conservator type with breather connections to inertaire equipment furnished with the transformers. A practical advantage of oil filled cable has already been demonstrated by the detection of a hole in the lead sheath through oil leaking into the manhole before the cable failed. Except for the auxiliary generator and transformer all auxiliary power and control cable is of the varnish cambric insulated armored type. Bronze armor over lead is used wherever the cable is exposed to moisture. When installed indoors the cables are routed through metal raceways consisting of 8-in. square duct with one removable side. The cables installed outdoors are of Parkway type buried in trenches with creosoted planks between layers of cables. The 2300-v. auxiliary generator and transformer cables are single conductor, varnished cambric insulated, lead covered.

Practically all motors used in the station are of the squirrel cage induction type and are designed for full voltage starting. All motors are arranged for push button control either from the boiler control boards or from a point immediately adjacent to the motor. In the majority of cases the push buttons are located on pedestals close to the motor.

Makeup Low

Changes made in equipment and in operation since the plant went into service are all of a very minor nature, perhaps the most interesting being in connection with the feedwater system. Makeup to the system is evaporated and is a small percentage averaging but 0.35

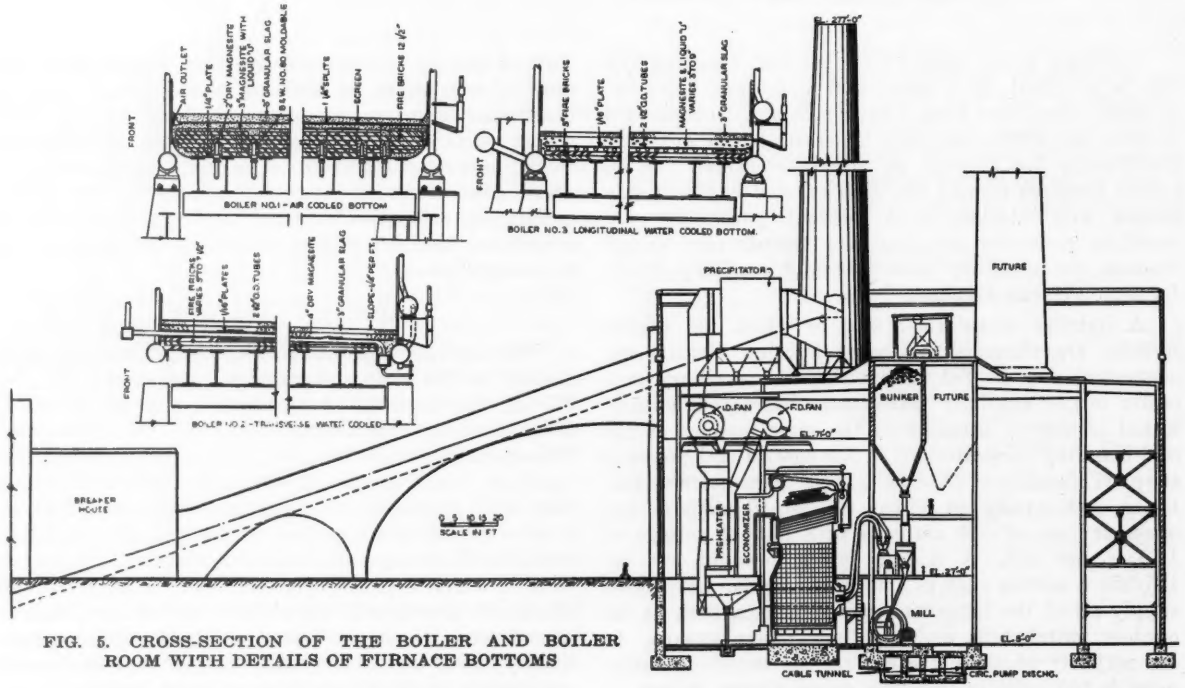


FIG. 5. CROSS-SECTION OF THE BOILER AND BOILER ROOM WITH DETAILS OF FURNACE BOTTOMS

PRINCIPAL EQUIPMENT MICHIGAN CITY STATION

Location .....Michigan City, Indiana
Owners.....
Northern Indiana Public Service Co.
Consulting Engineers....Sargent & Lundy
Architects.....Holabird & Root
Property area.....28 acres
Present Building (including space for Unit No. 2), vol. cu. ft. per kw.

Boiler Room	35.4
Turbine Room	34.7
Switch and Cable Rooms	2.8
Switch House	1.9
Pump and Screen Room	5.4
Office	1.3
	81.5

Boilers—Babcock & Wilcox Co., 3, 7917 sq. ft., cross drum boilers with a maximum capacity of 345,000 lb. of steam per hr. Steam conditioned superheater outlet 680 lb. gauge, 770 deg. F.

Superheaters—The Superheater Co., 3, convection type, 5072 sq. ft.

Economizers—Babcock & Wilcox Co., steel contra-flow with a surface of 14,929 sq. ft. each.

Air Heaters—Buffalo Forge Co.. 3 tubular type with a surface of 42,000 sq. ft. each.

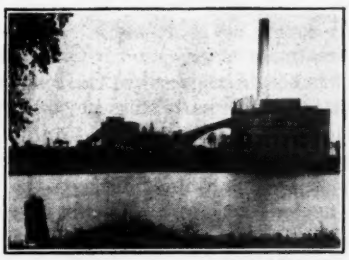
Furnaces—Fuller Lehigh Co., 3 slag tap bottom and Bailey wall; No. 1 with air cooled bottom and Nos. 2 and 3 with water cooled bottom. Volume 14,700 cu. ft. each; side wall surface 2250 sq. ft.

Pulverized Fuel Equipment—Boiler Nos. 1 and 2, Kennedy-Van Saun Mfg. & Engrg. Corp., 2, 8 ft. diam. by 10 ft. long air swept tube mills with capacity of 12½ t. per hr.; 8 vortex mixing type burners per boiler.

Pulverized Fuel Equipment—Boiler No. 3, Fuller Lehigh Co., 2 type B, 46 in. diam., air separation table mills with capacity of 12½ t. per hr. This boiler has 4 cross-tube type burners.

Forced Draft Fans—B. F. Sturtevant Co., 3, Turbovane with capacity of 96,000 c.f.m. each 8½ in. water pressure and 1160 r.p.m., fan on No. 1 boiler driven by 100 hp. 870 r.p.m. and 200 hp. 1160 r.p.m. motor; fans on Nos. 2 and 3 boilers by 200 hp. 1160 r.p.m. motors.

Induced Draft Fans—B. F. Sturtevant Co., 3 double inlet Turbovane, with capacity of 178,000 c.f.m. at 404 deg. F. gas pressure, 13 in. water; fan No. 1 boiler driven by 350 hp. 700 r.p.m., and 600 hp. 870 r.p.m. motors; fans on Nos. 2 and 3 boilers driven by 600 hp. 870 r.p.m. motors.



Boiler Settings—Geo. Allen & Sons, for 3 boilers, furnace bottoms and economizers, first quality firebrick 78,800, second quality 22,600.

Economizer Arches—M. H. Detrick Co.

Turbo-Generator—Westinghouse Elec. & Mfg. Co., 1, 68,000 kw., 650 lb. gauge, 750 deg. F., 1800 r.p.m. turbine driving a 22,000 v., 70,600 kv.a., 0.906 p.f., 3 ph., 60 cycle, 14 per cent reactance main generator; a 350 kw., 250 v. shunt wound exciter; a 5714 kv.a., 0.70 p.f., 2300 v.. 3 ph., 60 cycle 13 per cent reactance auxiliary shaft generator and a 70 kw., 250 v. shunt wound exciter.

Condenser—Allis-Chalmers Mfg. Co., 1 horizontal single pass, 50,000 sq. ft. condenser with ⅞ in., 18 B.W.G., 25 ft., 70-30 mixture brass tubes rolled at both ends; condensing capacity 550,000 lb. per hr.

Vacuum Pumps—Croll-Reynolds Co., 1 3-stage steam jet air pump, 4 nozzles per stage, combined inter and after coolers; capacity 31 c.f.m. at 1 in. abs. with steam consumption 750 lb. per hr.

Circulating Pumps—Allis-Chalmers Mfg. Co., 2, 54 in. x 48 in. single stage vertical pumps with a capacity of 42,500 g.p.m. each against a total head of 14 ft., driven at 145 r.p.m. by 250 hp. motors.

Condensate Pumps—Allis-Chalmers Mfg. Co., 2, 10 by 5 in., center suction, 2-stage centrifugals, with capacity of 1200 g.p.m. each at 280 ft. head, driven at 1150 r.p.m. by 175 hp. motors.

Extraction Heaters—Foster Wheeler Corp., 2 low pressure and 2 high pressure, vertical, floating head type closed heaters.

Heater Drain Pumps—DeLaval Steam Turbine Co., 2, two-stage centrifugal, intermediate heater pump, 250 g.p.m., with head of 125 lb., driven at 1760 r.p.m. by 40 hp. motor; low pressure heater pump, capacity 150 g.p.m. against 125 lb. pressure, driven at 1760 r.p.m. by 30 hp. motor.

Evaporators—Griscom-Russell Co., 2 bent tube type with capacity of 30,000 lb. distilled water per hr.

Evaporator Condenser—Griscom-Russell Co., vertical, floating head, with capacity of 20,000 lb. vapor per hr.

Evaporator Condenser Drain Pump—DeLaval Steam Turbine Co., 1, 2-stage centrifugal with capacity of 75 g.p.m. at 120 lb. head, driven at 1760 r.p.m. by 20 hp. motor

Water Filter System—Paige & Jones, 2 units, gravel filter and tank, capacity each 150 g.p.m.

Boiler Feed Pumps—Ingersoll-Rand Co., 3, 5 in. 6-stage, 1760 r.p.m., Cameron centrifugals with capacity of 800 g.p.m. against 900 lb. head. One driven by Terry steam turbine, 2 by motors.

Service Pump—Ingersoll-Rand Co., 3, 8 in. single-stage, 1760 r.p.m., Cameron centrifugals, with a capacity of 2000 g.p.m. each, against head of 198 ft.; 2 pumps driven by motor, 1 by turbine. At a higher speed of 2250 r.p.m. the turbine pump will deliver 2000 g.p.m. against head of 349 ft.

Ash Sluicing Pump—Ingersoll-Rand Co., 1, 8 in. two-stage, centrifugal with capacity of 2000 g.p.m. against head of 349 ft. at a speed of 1750 r.p.m., driven by 250 hp. motors.

Sludge Pumps—Allen-Sherman-Hoff Co., 2, 8 in. vertical shaft centrifugals, capacity of water and ash 2000 g.p.m. delivered to any point at grade elevation within a radius of 500 ft., driven by 150-hp. motor.

Ash Handling Equipment—Allen-Sherman-Hoff Co. slag disintegrating chambers and Hydrojet handling.

Bilge Pumps—Yeomans Bros. Co., 12 vertical motor driven centrifugals, with capacity of 200 g.p.m. each at a speed of 1165 r.p.m.; 6 in turbine room with head of 46 ft.; 2 in auxiliary switch room with head of 75 ft.; 2 in pump and screen room with 75 ft. head; 1 at track hopper with 75 ft. head; 1 in breaker building with 42 ft. head.

Dust Collectors—Research Corp., 2, with normal capacity 165,000 c.f.m. each of 360 deg. F. gas; maximum capacity 240,000 c.f.m. each of 400 deg. F. gas. Pressure drop at max. rating 0.4 in. water, guaranteed recovery at normal rating 90%.

Turbine Room Crane—Whiting Corp., 1 double trolley with span of 129 ft. 10 in., lift of 62 ft. 2 in. with 75 t. main hoist and 15 t. auxil. hoist.

Traveling Screens—Chain Belt Co., 2, 7 ft. 10 in. wide, 27 ft. 6 in. between centers, speed 10 ft. per min.

Coal Handling Equipment—Koppers Co., breaker belt conveyors with capacity of 250 t. per hr., belt conveyors 42 and 36 in. wide, speeds 180 to 250 ft. per min.

Track Scale—Fairbanks, Morse & Co., 60 ft. in two sections, capacity 200 t. per section.

Coal Unloading Crane—Shepard-Niles Crane & Hoist Corp., 4-motor traveling grab bucket gantry crane with 3 cu. yd. bucket, capacity 250 t. per hr.

Automatic Coal Sampler—Charleroix Iron Works.

Coal Feed Scales—Richardson Scale Co., 6 automatic apron feed, capacity 400 lb. each.

Air Compressors—Sullivan Machinery Co., 2 stage angle compound driven by 150 hp. motor with Texrope drive, capacity 745 c.f.m. at 100 lb. pressure, 342 r.p.m. speed.

Condensate Meters—Simplex Meter Co.

Boiler Feed Meters—Builders Iron Foundry.

Condenser Leakage Meters—Leeds & Northrup.

Electric Equip. Erection—Pierce Elec. Co.

Storage Battery—The Electric Storage Battery Co., 2, 80 amp. for 8 hr., 250 v. batteries.

Miscellaneous Motors—Fairbanks, Morse & Co.

Automatic Telephone—P-A-X.

Superstructure—Herlihy Mid-Continent Co.

Dredging—Great Lakes Dredge & Dock Co.

Flues, Uptakes and Airducts—United Boiler Heating & Fdry. Co.

Insulation—Keasbey & Mattison Co.

Piping System—W. A. Pope Co.

Circulating Line, Fittings and Motor Operated Gate Valves—Crane Co.

Power Transformers—Westinghouse Elec. & Mfg. Co., 4, 25,000 kv.a., 22,000 volt delta to 138,000 volt "Y", single-phase, 60-cycle, water cooled, with 4 3% taps above and below 138 kv. and load ratio control. Also 4, 5000 kv.a., 13,200 v. to 76,300/132,000 v. with 33,000 v. tertiary, single-phase, 60-cycle, salt cooled. (These forming original Hoosier Slide Substation installation.)

Auxiliary Transformers—Westinghouse Elec. & Mfg. Co., 2, 6000 kv.a., 22000/2300 v., 3-ph., 60-cycle, salt cooled with 2-5 per cent full capacity taps above and below high tension winding. Also 3, —750 kv.a., 2300/440 v., 3-ph., 60-cycle transformers.

High Tension Oil Circuit Breakers—American Brown Boveri Co., Type BO-60, 660 amp., 3 pole, 138 kv., 60 cycle, 250 v., d.c., motor operated, interrupting capacity 8750 amp. at 132 kv. Condit Elec. & Mfg. Co., 400 amp., 3 pole, 37 kv., 60 cycle, 250 v. d.c., solenoid operated, interrupting capacity 12,000 amp. at 37 kv. (Original Hoosier slide Substation installation.) Westinghouse Elec. & Mfg. Co., type 0-551, 3000 and 600 amp., 3 pole, 37 kv., 60 cycle, 250 v., d.c., solenoid operated, interrupting capacity 23,500 amp. at 37 kv. 400 amp., 3 pole, 132 kv., 250 v., d.c., solenoid operated, interrupting capacity 6500 amp. at 132 kv. (Original Hoosier Slide installation.)

Low Tension Oil Circuit Breakers—Westinghouse Elec. & Mfg. Co., Type B-8, 2000 amp., 3 pole, 15 kv., 60 cycle, 250 v. d.c., solenoid operated, interrupting capacity 37,500 amp. at 2500 v., also Westinghouse Elec. & Mfg. Co., Type B-20, 600 amp., 3 pole, 7500 v., 60 cycle, 250 v., d.c., solenoid operated, interrupting capacity 37,500 amp. at 2500 v.

Low Tension Air Circuit Breakers—I-T-E Circuit Breaker Co., 1200 amp., 440 v., 3 pole, 60 cycle, 250 v., d.c., solenoid operated, interrupting capacity 35,000 amp. at 600 v. (Auxiliary power distribution).

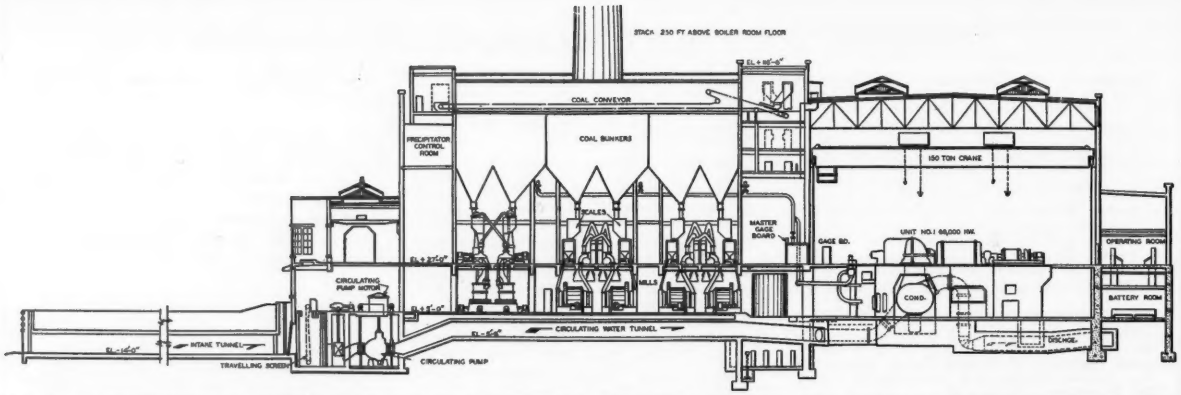


FIG. 6. LONGITUDINAL SECTION OF STATION SHOWING LOCATION OF THE TWO SWITCH ROOMS BETWEEN THE TURBINE AND BOILER ROOMS

per cent over the year. Evaporators are operated continuously at as low a rate as possible, usually from 3000 to 5000 lb. per hr.

Evaporator feed is harbor water filtered through a sand filter and taken from the service water lines. Until recently no evaporator feed treatment was used but now a batch lime treater is used and about a quart of lime added for every 100,000 lb. of water evaporated. This treatment was added to reduce the CO_2 in the evaporator vapor. The lime has not only reduced the CO_2 thus increasing the pH reading of the distillate but has reduced carryover and eliminated scaling. Previously the evaporator was cracked every 24 hr. Now the unit can be run for 72 hr. without blowing down and the impurities settle down in a sludge easily blown out without cracking.

As shown on the heat balance diagram, Fig. 2, this makeup enters the system preceding the B heater and is later stored in the surge tank or hot water reservoir at a temperature of about 120 deg. F. This reservoir takes care of load fluctuations, water to or from storage being controlled by a high water and low water float in the condenser hotwell.

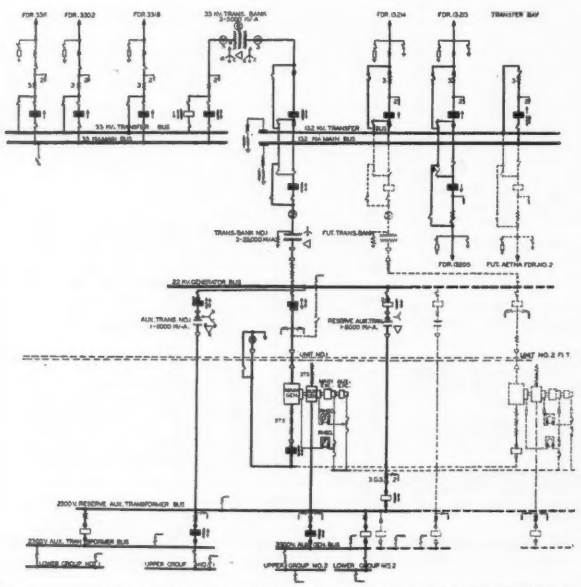


FIG. 7. SINGLE LINE DIAGRAM OF MAIN CONNECTIONS

This was one point where early difficulty developed. The deaerating condenser hotwell is fitted with an internal hood to conduct liberated gases to the air cooler section of the tube bank. The low level float chamber was originally installed with the upper connection above this hood. During periods of increasing load the boiler feed pump would pull down the level, opening the valve from the storage reservoir. Incoming water at about 120 deg. F. would flash, building up a slight pressure which would tend to close the valve in spite of the falling water level. This condition was corrected by lowering the upper float connection below the cone so that both connections were subjected to the increased pressure.

Because of small wearing ring clearance and the extreme temperature changes between the feed pump when idle and in service, some rubbing took place. This was corrected by increasing the clearance to 0.015 in. and keeping the spare feed pump warm by means of a bypass line, with a 9/32-in. orifice, around the discharge and check valves. With the suction valve open the circulation is sufficient to keep the pump warm so that there is no binding between the stationary and rotating parts when starting. The necessary orifice size was found by experiment.

No boiler water treatment of any kind is used. Practically no corrosion has been discovered in the economizers, and none in the boilers, superheaters or steel tube closed heaters. Some recirculation, about 1 to 1.5 per cent, from the upper water wall header to the suction of the boiler feed pump is maintained to keep the pH value in the lines neutral or above. The boilers are never blown down although the water is drained to the sewer when boilers are emptied.

Turbine Room

No turbine trouble has developed and during the inspection in January, after one year's operation, the blading was found to be in good shape except that small pieces of the Everbright nozzle blocks had lodged in the high-pressure section. The first rows of reaction blades were bent but all the blades were intact. The cracked nozzle blocks were replaced with stainless steel by the manufacturer and the turbine water rate came up to its original value. Stellite shielding strips on the last row of turbine blades are proving effective in preventing erosion in spite of 13 to 14 per cent moisture in the steam at exhaust. The tip blade speed is 1115 ft. per sec.

No deposits were found in the blades in spite of the fact that no cracking is done and the turbine is seldom stopped. This is attributed to the fact that no chemicals are added to the boiler water, other than the slight amount getting into the system from the condenser leakage and evaporator carryover.

Major outage periods for 1931 can be located on Fig. 3 and are as follows:

Outage of 66.1 hr. for bearings. In starting turbine after it had been down for oil piping changes, a rub developed on the outboard water seal gland. The machine was shut down and upon inspection the gland runner was found broken and the out thrust blocks were found wiped.

Outage of 40.7 hr. for throttle valve. Trouble had developed previously when attempting to bring the machine up to speed, as the governor would start oscillating and the throttle valve would shut. Upon inspection it was found that the nitrided seal ring installed on the piston in the throttle valve body had broken into a large number of pieces. This was replaced with a common cast iron ring.

Outage of 22.0 and 14.37 hr. for internal fan in generator. One blade of fan for cooling generator broke off and broke the castings forming the housing. The housing was patched and replaced. The blade opposite the broken blade in the fan was cut off for balancing.

Outage of 26.62 and 18.05 for governor and control gear. This time was spent making adjustments to the hydraulic governor and mechanism.

Oil Piping

In order to minimize the danger of fires from oil leakage around or on hot steam pipes an oil guard has been placed around the steam chest completely covering the front, back and ends and forming a pan underneath. From this pan is a large drain to the gutter and bilge pump with a suitable telltale to warn the operator in case of a small leakage which might go undetected. The top of this shield comes just above floor level and covers the oil line in front of the valves in the photograph shown on the second page of this issue which was taken before the change. This leaves the only exposed hot surfaces inside the valve around the valve stem. These spaces are filled with a high temperature cement built up high around a loose fitting valve rod sleeve.

Boilers

No changes have been made in the boilers and furnaces with the exception of reducing the air cooled area of No. 1 furnace. Details of this bottom are shown in Fig. 5. Originally this was entirely air cooled and two leaks developed down through the air cooling pipes. Slag ran down the air piping and contrary to what might be expected hardened around the periphery of the pipe, gradually filling it up until only a small circular passage in the center of the pipe remained.

Later the air cooling pipes were removed from the center section leaving a solid bottom with only a strip 4 ft. from the walls air cooled. Both No. 2 and No. 3 furnaces are watercooled although the details differ slightly as shown by Fig. 5. On No. 2 the water tubes enter the front wall from a header and curve downward to a box header as shown in the drawing. In No. 3 the water tubes pass across the furnace through the water walls on each side*. There seems little to choose between them except that the header on No. 2 is more difficult to reach.

Another interesting experience illustrating the close attention to detail which must be exercised in a modern station was in connection with the automatic coal sampler in the breaker house. The sampler is located below the breaker just before the second belt. The discharge of the first belt is down through the breaker to the second belt and apparently falling coal acts like a hydraulic compressor to build up a positive pressure. Moisture in the air trapped in the sampler hopper condensed out and caused the wet fine coal to bridge over and stick. This condition was relieved by tapping a vent in the pipe to relieve the pressure. The vent discharges through a duck bag to prevent the discharge of coal dust with the air.

Another detail which prevented the sampler from giving a representative sample by causing a segregation of lump and dust was not found for several months.

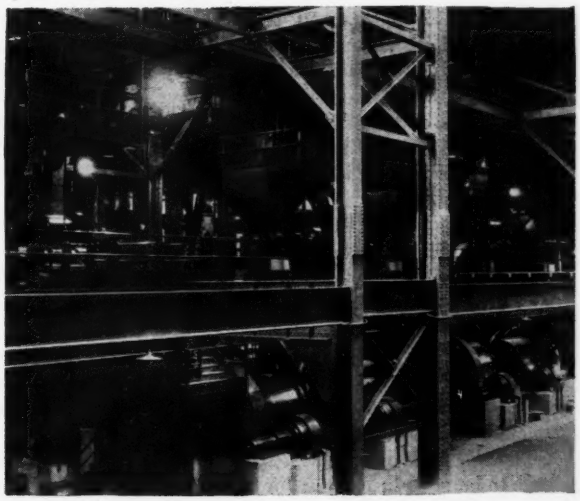


FIG. 8. BOILER ROOM SHOWING THE BALL MILLS AND BOILERS NOS. 1 AND 2

During this period the heating values of the sampler ran about 275 B.t.u. high as mentioned previously. After this mistake was discovered the station performance figures were not corrected which accounts for a considerable portion of the 1 per cent the station ran below bogey.

Pulverized coal samples are taken carefully and only under standard conditions so that results are comparable from day to day. These samples are collected only when the pulverizers are operated under the standard conditions.

Experience with Petroleum Coke

During the past summer petroleum coke screenings were burned for a period of 3½ mo. because labor difficulties in the Indiana coal fields interrupted the coal supply. The coke finally selected had the following analysis expressed in percentage as fired: Moisture, 5.66; volatile, 15.02; fixed carbon, 77.15; ash, 2.17; sulphur, 1.27; B.t.u. per lb., 14,925. Further details of this period will be given in a subsequent article.

*For details regarding the furnace bottom see Slag Tap Furnaces by A. L. Baker, presented before the Fourth National Fuels meeting of the A.S.M.E. at Chicago, Feb., 1931. A.S.M.E. Transactions of the A.S.M.E., Vol. 54, No. 1.

POWER PLANT ENGINEERING December 1932

Significance *of* Efficiency *in* Power Plant Economics

By
THEODORE MAYNZ
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Savings in Fuel May Be An Economic Waste If Purchased at Too High a Price. A Method Is Given for Calculating Allowable Investment.

NOW THAT we have reached boiler plant efficiencies of over 90 per cent and can generate a kw-hr. on one pound of medium grade coal, have reached steam pressures of 1400 lb. and temperatures close to 1000 degs. F. and, to accomplish this, have built our plants rather complicated, using heat recovery equipment to a degree that was unthought of but 12 yr. ago, are using reheat cycles and multiple feedwater heating stages, let us examine just how far it is economically profitable to design for present or increased efficiency.

Though many varieties of fuels are used and available, the use of bituminous coal is more widespread, both for industrial concerns and public utilities, than any other and, in most localities, it is by far the cheapest fuel available. The price of coal is low, especially for the sizes used for steam generation, and there seems to be no reason why its cost should increase materially for many years. Thus with coal as the basic fuel, we can assume its present cost as that prevailing for the economic life of the plant.

The question of fuel cost for the generation of steam alone, to be used in process for manufacturing a product, is quite different from that of a central station, where the sale of electricity is the major business. In the first case, the use of steam might be a small portion of the factory cost of the product and thus the saving of fuel of but slight importance, when total costs are considered. In the manufacture of electric power and light, though the cost of fuel is the largest item in the cost of production, nevertheless it is not nearly as large a factor in the cost of the delivered product as is generally supposed.

Cost of Efficiency

By making a few rational assumptions and some simple calculations, we can determine closely how much we can spend for increased efficiency, either for the manufacturer of electric power, as in a public utility system, or for process steam in an industrial factory.

For the manufacture of process steam alone, a medium size boiler, stoker or pulverized coal fired, without the use of any heat recovery equipment (except for a feedwater heater), operating at medium ratings of 6 lb. of steam per sq. ft. of boiler heating surface (approximately 180 per cent of rating) can be expected to have a net efficiency of 72 per cent, using a reasonably good grade of coal. Assuming no superheat is required, the steam will contain about 1200 B.t.u. per lb. over a wide range of pressure, varying only 10 B.t.u. or 8 per cent from 150 lb. to 300 lb. gage. Thus, with 212 deg. feedwater temperature, we can get, at this efficiency, an evaporation of 9.2 lb. of steam per pound of 13,000 B.t.u. coal, or 10 lb. evaporation with 14,200 B.t.u. coal.

If the unit is operated for 7000 hr. per year, it will produce 42,000 lb. of steam per year per sq. ft. heating surface. With 13,000 B.t.u. coal, the fuel consumed will be 4570 lb. or a little over 2¼ t. of coal per year. Assuming the cost is $3.00 per ton, delivered, the fuel consumed per sq. ft. of boiler will be $6.85 per year. Fuel cost alone, per 1000 lb. of steam is $0.163.

If we should add heat recovery equipment to increase this efficiency 5 points, to 77 per cent net, for the same output of 42,000 lb., the heat input would be reduced from 59.5 million to 55.7 million B.t.u., saving 3.8 million B.t.u. or 292 lb. of coal per year, worth $0.438. This is a saving of 6.4 per cent of the coal cost.

As our invested capital should earn a net of 10 per cent after the required fixed charges, to make the investment attractive, the total return should be not less than 25 per cent. Therefore the saving entailed by this 6.4 per cent increased efficiency, saving $0.438 per year, will allow us to spend $0.438 \div 0.25 = \$1.75$ capital per sq. ft. of boiler surface. Translating this to a 1000-hp. boiler, we can spend an additional $17,500 for heat recovery equipment that will save a net of 6.4 per cent of the fuel, a gross money saving of $4380.00 per year. The net saving, after deducting the 15 per cent fixed charges, will be $1750.00 per year, for an increase of from 72 to 77 per cent boiler efficiency. Assuming that this 1000-hp. boiler costs $100,000 installed, we can afford to spend 17.5 per cent additional capital to save 6.4 per cent of the fuel, or approximately three times the fuel saving percentage.

The law of diminishing returns affects the net savings. To increase the boiler efficiency from 85 to 90 per cent will save 2.8 million B.t.u. or 5.55 per cent of the fuel. This amounts to 215 lb. coal per sq. ft. per year, or $0.323 per year. For a net return of 10 per cent, the maximum capital investment would be $0.323 \div 0.25 = \$1.29$ per sq. ft. of boiler, considerably less than for the lower efficiency.

Calculations Applied to Economizer

If an economizer is used to increase the boiler efficiency the 5 points from 72 to 77 per cent, we must add 65 B.t.u. to each of the 6 lb. of steam produced per operating hour by each sq. ft. of boiler surface, a total

of 390 B.t.u. per hour. Under normal design, this would require an economizer of about 55 sq. ft. surface per 1000 lb. of steam, or 0.35 sq. ft. per sq. ft. of boiler. Estimating the cost at $4.00 per sq. ft. of economizer, including fans, drives, dampers and foundations, the total cost of $1.40 would be less than the amount our calculations show we can afford to spend, and would permit an increased size of economizer, and a larger net return on the investment. Similar figures could be set up for an air preheater, or combination of air heater and economizer.

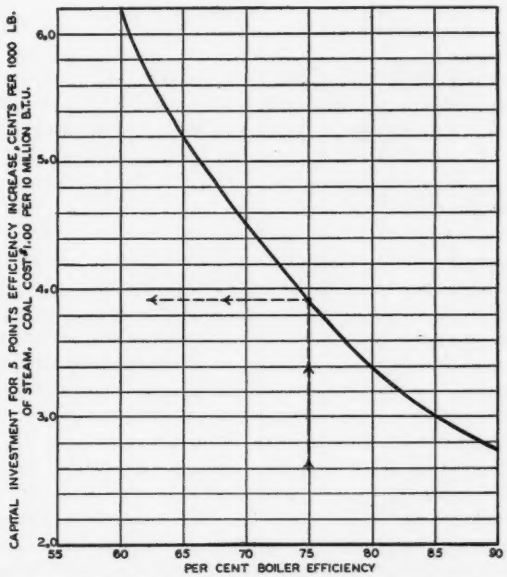
In the generation of power and steam, both the load factor and the price of fuel are determining factors. The law of diminishing returns, however, also affects the amount of return from invested capital. The accompanying curve shows this distinctly. This curve shows the allowed amount of investment to return a net of 10 per cent per year for each 1000 lb. of steam generated per year, for each 5 points increase in efficiency. Coal cost is $1.00 per 10 million B.t.u. as standard, and therefore requires a simple correction for different coal costs and heat values. Thus for a $3.00 and 13,000 B.t.u. coal, the correction would be $(3 \times 10^7) \div (13{,}000 \times 2000) = 1.15$ and for $4.00 and 14,500 B.t.u. coal the factor would be 1.38. The example on the curve sheet shows that we can afford to spend $0.0392 capital per 1000 lb. of steam per year for an increase of from 70 per cent to 75 per cent boiler efficiency. Thus with the 42,000 lb. of steam per sq. ft. heating surface generated per year and $3.00 coal, we can afford to spend $0.0392 \times 1.15 \times 42 = \$1.89$ for each sq. ft. of boiler heating surface.

Basis of Calculations

In the generation of power we can base our calculations either on a B.t.u. saving basis, or a percentage basis. Since power plant efficiency is commonly rated on the B.t.u. per kw-hr. performance of a station, we will use this method. Saving 1000 B.t.u. on a 20,000 B.t.u. station is a fuel saving of 5 per cent, while to save the same amount in a 13,000 B.t.u. station means 7.7 per cent fuel saving, even though the money saving is the same for similar coals. Thus in the more efficient station the law of diminishing returns shows a 50 per cent increased percentage saving for an equal money saving.

Operating under a 40 per cent capacity load factor, each kilowatt of installed capacity will produce 3500 kw-hr. per year. Again requiring a 10 per cent net earning with 15 per cent fixed charges from our invested capital, we can afford $(35 \div 25) \times 1.15 = \$1.61$ additional capital per installed kilowatt for a 1000 B.t.u. per kw-hr. saving with $3.00 coal.

Thus if it costs $90 per kw. to build a 20,000 B.t.u. plant, we can spend 1.79 per cent additional capital for a 5 per cent increase in efficiency, while for a 13,000 B.t.u. station costing $110 per kw. to build, we can spend 1.46 per cent additional capital for a 7.7 per cent increase in efficiency, both based on 40 per cent capacity factor and $3.00, 13,000 B.t.u. coal. Naturally with increased coal costs we get increased returns on the investment. A reduction in fuel costs for the generation of power, however, is relatively of minor importance compared to the delivered cost. Whereas the generating station will cost about $100 per kw., the distribution system, franchises, rights of way, and working capital will cost an additional $150 per kw., making the total cost about $250 per installed kw. Fixed charges, including allowed earnings, will amount to 15 per cent, a total of $37.50 per yr. per kw. This amounts to $0.0107 per kw-hr. generated, from 5 to 7 times the fuel cost with $3.00 coal.



ALLOWABLE INVESTMENT CAPITAL EXPENDITURE FOR 5 POINTS INCREASED BOILER EFFICIENCY PER 1000 LB. STEAM PER YEAR

We can see therefore, that we can afford considerable capital expenditure for increased boiler efficiency, but to increase the efficiency of a generating station requires an extremely careful consideration on the net return before the expenditure for heat recovery equipment.

Loans applied for to the Reconstruction Finance Corp. which are of self-liquidating character and involve power plant construction are in final form to the extent of 30 water supply systems aggregating $3,309,120 and 5 power plants to cost $6,859,000. Applications for which data are not yet complete include 16 water supply systems for $20,484,000, 7 irrigation systems for $2,523,956, 5 power plants for $32,670,000, a hospital for $250,000. Informal applications on which little data are available involve 39 water supply systems for $36,439,257, 9 irrigation systems for $18,279,000, 4 power plants for $980,000, a drainage system for $83,000. Four projects not in final form are being expedited by engineering assistance from 37 engineers acting as members of advisory committees throughout the country, but this work is not intended to replace proper engineering service which applicants should employ.

Among papers presented at the fall meeting of American Welding Soc., 33 W 39th St., New York, are one on Tests of Welded Butt-Strap Joints by S. C. Hollister, papers on Welding of Pressure Vessels by P. R. Hawthorne and Dr. J. C. Holmberg, also by H. L. R. Whitney, and R. L. Shepard. The meeting was held in Hotel Statler, Buffalo, N. Y., Oct. 3 to 7.

POWER PLANT ENGINEERING December 1932

Reheat—Practice, Operation and Control

REGULATION OF INITIAL AND REHEAT STEAM TEMPERATURES BY COMBINATION SUPERHEATERS, SUPERHEATER LOCATION AND BAFFLING. APPLICATION OF REHEATERS TO MEET NEEDS OF TURBINES OPERATING UNDER CONSTANT AND VARIABLE REHEAT PRESSURES

TOTAL STEAM TEMPERATURES, both initial and reheat, can be controlled in several ways,[1] perhaps the simplest being the proper selection and proportioning of superheater surface to take advantage of the contrasting characteristics of the two types, convection and radiant.

In general total steam temperatures leaving a convection superheater increase with the load as shown by the lower curve of Fig. 1. This is because the gases sweeping over the elements are hotter and have a higher velocity at the higher ratings. Steam velocities are also higher. Higher velocities give higher heat transfer coefficients, which with the greater heat head due to the hotter gases tend to increase the steam temperature.

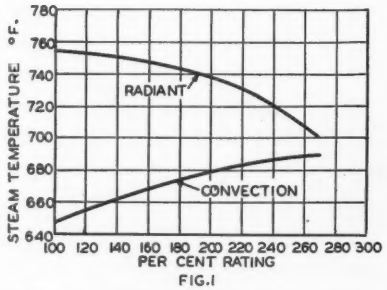
Radiant superheaters on the other hand give lower temperatures at the higher ratings as shown by the upper curve of Fig. 1. Practically all the heat transfer takes place by radiation from the hot gases in the furnace and this is primarily a function of the temperature difference between these gases and the walls of the heating elements. Furnace temperature does not change greatly with rating so that there is an almost constant total heat transfer which of course means a lowering of the steam temperature as the steam flow increases.

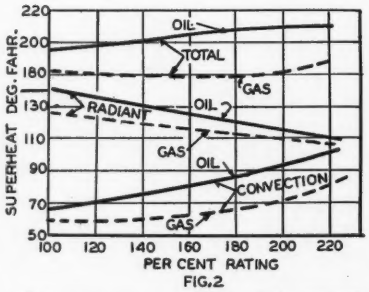
[1]See POWER PLANT ENGINEERING, p. 703, Aug., 1932.

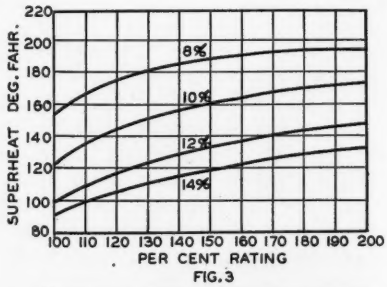
Many stations have taken advantage of these opposed characteristics[2] to give a practically constant superheat at all ratings. One such installation is shown by the solid line of Fig. 2. A temperature variation of 30 deg. F. (practically 30 per cent) with either type superheater was reduced to about 15 deg. F. (about 7.5 per cent), by using a combination of surfaces. Another boiler of the same type and size but with a larger proportion of radiant surface showed a decrease of about 15 deg. F. in superheat instead of an increase of this amount as in Fig. 2. It is evident that the surfaces can be proportioned to give practically any desired result.

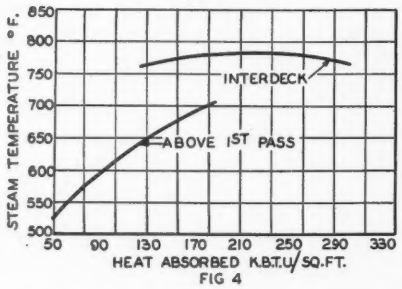
It must be understood that these characteristics are influenced by many factors, among which may be mentioned, the kind of fuel; CO_2 content of the flue gases; position with reference to the furnace and boiler baffling. For instance gas gives a much lower superheat than oil firing with either type of superheater as indicated by the difference between the dotted and solid lines of Fig. 2. This same variation is evident when the CO_2 content is changed as shown by Fig. 3, higher CO_2 content giving lower superheat and a flatter characteristic.

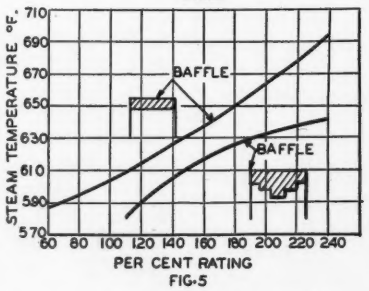
[2]See POWER PLANT ENGINEERING, p. 427, April 15, 1930.











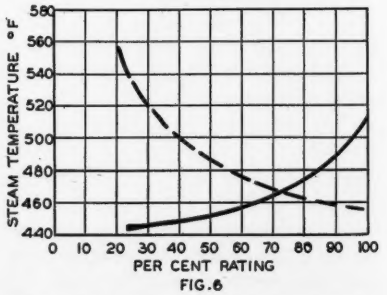


FIG. 1. RADIANT AND CONVECTION SUPERHEATERS HAVE DIFFERENT CHARACTERISTICS

FIG. 2. BY COMBINING RADIANT AND CONVECTION ELEMENTS IN SERIES AN ALMOST CONSTANT SUPERHEAT CAN BE OBTAINED OVER THE ENTIRE LOAD RANGE

FIG. 3. CO_2 CONTENT CHANGES THE SUPERHEAT AND HAS A SLIGHT EFFECT ON THE SHAPE OF THE CHARACTERISTIC CURVE

FIG. 4. IN THIS BOILER THE CONVECTION SUPERHEAT CHARACTERISTIC WAS CHANGED BY ADDING ADDITIONAL SURFACE AND MOVING THE ELEMENTS 8 TUBES NEARER THE FURNACE

FIG. 5. CONVECTION SUPERHEAT CHARACTERISTIC CHANGED BY BAFFLING THE GAS FLOW

FIG. 6. TEMPERATURE OF STEAM TO THE REHEATER TURBINE EXHAUST DEPENDS UPON THE METHOD OF TURBINE OPERATION

Location of the heating element in relation to the furnace is important. As the superheater is moved closer to the furnace, where it is swept by hotter gases, the superheat is increased while the effects of the radiant heat transfer change the characteristic considerably. At high loads 50 per cent or more of the heat transfer to a modern interdeck convection superheater may be by radiation. Single interdeck superheaters at high ratings are in effect combination superheaters and can have a flat characteristic over a considerable load range.

Effects of changes in location are shown by Fig. 4. In this boiler water walls were added to increase the capacity of the unit. Increased economizer surface was added and the superheater, originally located above the first pass was tripled in size and made interdeck.

Baffling is also extremely important, Fig. 5 showing changes in the superheat characteristics of an interdeck convection superheater made by baffle changes. The upper curve, with a baffle of uniform width across the front of the furnace just below the superheater was changed to the lower curve by making the baffle three times as wide at the center as at the sides of the furnace.[3] This upper curve is similar to that which may be obtained from a radiant superheater screened behind water wall tubes. These curves, included in a general discussion of this kind, are intended to show the effects of certain variables in design and operation and not to be used for design purposes.

Reheating to Superheat

It is obvious that these superheater characteristics can be taken advantage of in reheating as well as in superheating although the problem is somewhat different. Steam goes to the superheater at almost constant pressure and at saturation temperature, so that assuming reasonably constant quality, the heating load on the superheater elements is directly proportional to the load.

In the reheater the entering temperature and perhaps the pressure, varies with the load depending upon the turbine arrangement. For instance where a high pressure turbine is superimposed on a low pressure station as at Lakeside it operates against a constant back pressure and the temperature of the exhaust temperature decreases as the load increases, as in the dotted curve of Fig. 6. By using a convection reheater an almost constant reheat can be obtained automatically as in the case of a combination superheater. This is shown in Fig. 7 A by combining the turbine exhaust temperature curve at constant exhaust pressure from Fig. 6 with the convection superheater characteristics of Fig. 1.

In a turbine operating at variable exhaust pressure as the high pressure element of a cross compound unit, the exhaust temperature (and pressure) increases as the load increases. By using a radiant reheater an almost flat reheat temperature can be obtained as in the case of the constant exhaust pressure turbine. This is shown by Fig. 7B which is a combination of the exhaust temperature curve of Fig. 6 for the variable exhaust pressure turbine and the radiant superheater characteristic from Fig. 1.

Plants using all of these combinations are actually in use or under construction but the radiant elements have not been as popular as the convection type so that the other temperature regulation schemes previously described[1] have been developed. The most notable work with combination superheaters and reheaters has been done at Lakeside[4].

[3]See POWER PLANT ENGINEERING, p. 169, Feb., 1, 1928.

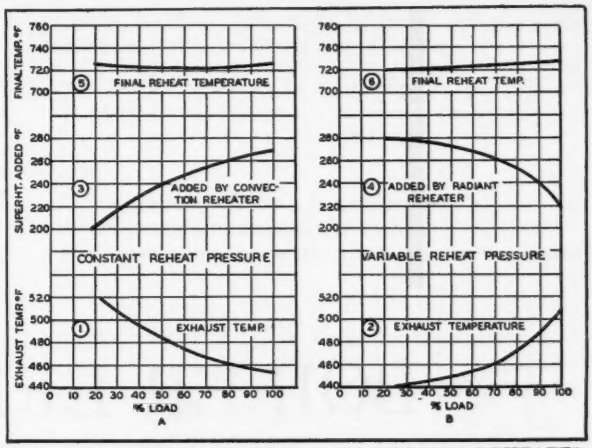


FIG. 7. (A) APPLICATION OF A CONVECTION REHEATER TO A TURBINE INSTALLATION OPERATING AT VARIABLE EXHAUST PRESSURE AND (B) A RADIANT SUPERHEATER TO A TURBINE INSTALLATION OPERATING AT VARIABLE EXHAUST PRESSURE TO GIVE A CONSTANT REHEAT TEMPERATURE AT ALL LOADS

At Lakeside the high pressure turbines operate at constant back pressure and the new high pressure boilers have radiant superheaters and convection reheaters. At the new Port Washington Station, now being built by the same company, the high pressure turbine will operate as part of a multivalve tandem compound unit. A combination superheater and a radiant reheater will be used to give the final temperature as shown by Fig. 8. Overload valves increase the slope of the exhaust temperature curve at high loads which accounts for the slight difference in the shape of the curves of Figs. 6 and 8.

Steam generation, superheating and reheating can all be done in a single boiler unit in which, by proper design and proportioning, almost any desired characteristic can be obtained and the temperature control problem largely eliminated without the use of steam heaters and other regulating equipment.[5]

[4]See POWER PLANT ENGINEERING, p. 830, Aug. 15, 1931.
[5]See POWER PLANT ENGINEERING, p. 484, June 15, 1932.

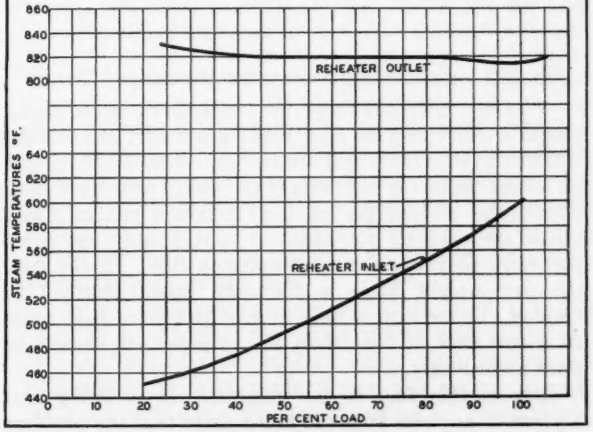


FIG. 8. PRACTICAL APPLICATION OF A COMBINATION SUPERHEATER AND RADIANT REHEATER TO AN 80,000-KW. UNIT FOR A STATION NOW BEING BUILT

POWER PLANT ENGINEERING December 1932

Hog Fuel Should Be Purchased on a Dry Basis Because the Moisture Content and Variable Density Make the Usual Unit or Volumetric Measure Worthless as a Standard of Value. Best Combustion Results Obtained with Highly Preheated Air in Properly Designed Furnaces. Probable Boiler Efficiency Can Be Calculated from Analysis and Should Be Made to Check Operation.

BOILER EFFICIENCY *and* WOOD WASTE FUEL

By
H. W. Beecher
C. C. Moore & Co.*

CUSTOM, dating back to the days when hog fuel had little commercial value, has decreed that hog fuel shall be sold by units of volumetric measurement; and now when we know that its sale should be by units of "weight of dry fuel" it may be difficult to convince all the parties concerned as to the advantage in changing.

Purchasers should always know how many B.t.u. are being obtained for their dollar. Without this information, how can one compare the hog fuel from one source with that from another? How can one tell whether to use kiln dried or wet refuse, hemlock or fir? What premium should one pay for one fuel over another per unit of volume? How can one run a boiler test?

Variations in the amount of steam that can be generated in the same furnace and with the same equipment per unit (200 cu. ft.) of fuel is surprising and may run up to 30 per cent. Unless the buyer checks on how much dry fuel he is getting per unit, he cannot tell from what source he should make his purchase. Still greater necessity for weight determination arises when the comparison also involves variation in moisture content.

Weight and Moisture Content Determine Value

Planing mill shavings are sometimes erroneously sought as fuel because they make a hot fire, are readily handled in conveyors and are low in moisture. If bought on a unit basis, the low weight per cubic foot more than offsets the advantages of low moisture content, and unless they can be purchased at considerably less price per unit, they are not a comparable fuel. In the end, the dry weight basis is the only logical method to employ. If one mill is able to give you more heat units in a car load of fuel than his neighbor, it should be paid accordingly.

How is this fuel to be weighed? It is bulky and a plant of any size burns so much daily that the problem is not easy. When fuel is transported in trucks or cars they can be routed over platform or track scales. The cost should not be great in the majority of cases. When fuel is handled in barges the weighing is more involved but for some time users of hog fuel have checked their results by getting the weight of fuel by the displacement of barges in which the fuel is transported. Belt scales have been used successfully to weigh sulphite chips and improved models should fit hog fuel.

Moisture determinations are simple and any mill laboratory is equipped to weigh, dry out and reweigh fuel samples. From this data percentage of moisture can be computed. With the weight as received and the moisture content, the number of B.t.u.'s can be computed using 8800 B.t.u. per pound as a factor.

The total B.t.u. content does not tell the whole story, with respect to the relative value of two fuels. A further analysis should be made taking into consideration the higher losses in the flue gas for high moisture fuels.

Air Preheaters

Due to the large amount of heat carried away in the chimney gases per pound of flue gas or per B.t.u. in the fuel, air preheaters are desirable and will usually be justified. Frequently, however, the results obtained are optimistically expressed in terms of the drop in gas temperature across the air heaters. This is misleading and because of air heater leakages and radiation losses, does not show the heat saving effected by the air heater. Performance results should show the heat returned to the boiler by the air heater. CO_2 determinations should be made frequently on both sides of an air heater to determine the air leakage.

Due to setting leakage, irrespective of type of fuel, the air contained in the boiler gases at boiler output does not all pass through the air heater. With hog fuel additional unheated air enters the furnace with the fuel. Usually calculations for air preheaters with hog fuel are

*With the Seattle office of C. C. Moore & Co., San Francisco, Cal. Taken from a paper presented before the Pacific Branch of the Technical Association of Pulp and Paper Industry.

based on from 70 to 85 per cent of the air being heated. The air entering with the fuel should be kept at a minimum by closed chutes, continuous feed and fuel seals or mechanical seals.

Air Leakage and Specific Heat of Gases

If it were possible to maintain bottle tight settings and preheat the air, we would still be unable to secure as much gas temperature depression as air temperature rise, because of two factors: first, the greater weight of gases than of air by the amount of the weight of fuel and moisture in the fuel; second, the higher specific heat of gases than of air.

Both the ratio of the weight of gases to the weight of air, and the ratio of the specific heat of gas to that of air vary directly as a function of the moisture content of the fuel and inversely as a function of the excess air. This results in a variable ratio between air temperature rise and gas temperature depression dependent on the moisture in the fuel and the excess of air.

In the past we have been somewhat limited as to safe total air temperature by the increased grate maintenance with high temperature air. By using properly designed and constructed water-cooled grates, this limitation is removed. Possibly additional refractory maintenance would indicate that the present preheated air temperatures should not exceed 500 deg. F. Assuming 500 deg. air as a safe limit and 80 deg. boiler room air temperature, we have a rise of 420 deg. This might permit gas temperature depression of 280 to 210 deg.

Boiler Efficiencies with Wood Refuse

Many plants have reported their boiler room efficiencies on the basis of available B.t.u. instead of comparing the B.t.u. imparted to the steam with that supplied in the fuel. Comparisons on the basis of available B.t.u. are misleading. The deduction from total B.t.u. to arrive at available B.t.u. will vary with exit gas temperature. This temperature will be high at high ratings and low at low ratings. It will also be less for any ratings if boiler has economizers or air preheaters.

It might be of interest to note the variation of efficiency with such factors as: stack or outlet temperature; moisture in the fuel; excess air. In building up an estimate of efficiencies to be secured from any fuel, certain assumptions must be made, a typical ultimate analysis must be used giving the percentage of carbon, hydrogen, oxygen, and nitrogen in the fuel. A radiation loss is assumed about three per cent of the heat in the fuel.

Unconsumed carbon loss is a matter of speculation. It consists of cinders that sift through the grates; cinders that lodge in cool parts of the setting where the gases that sweep them are too lean of oxygen to consume the incandescent carbon; cinders that carry through the setting and out the stack. Carbon that appears in the smoke is the result of the breaking up and partial consumption of hydro-carbons and is to be included in unconsumed carbon.

A typical ultimate analysis of wood on a percentage basis that is close enough to most woods to form a basis for calculations is: Carbon, 50.31; hydrogen, 6.20; oxygen, 43.08; nitrogen, 0.04; ash, 0.37; total 100.00. Using this analysis the author has prepared the accompanying chart for a convenient "efficiency prophesy".

Losses are given per pound of dry fuel and by adding the losses and deducting their sum from 8800 and then dividing the result by 8800, the prophesied efficiency is computed from the equation

$$E = \frac{8800 - (AB + C + DG + FK + 994 \text{ B.t.u.})}{8800}$$

Where

E = expected efficiency in per cent
A = Loss due to moisture in fuel of 50 per cent
B = Correction factor for A, other moisture contents

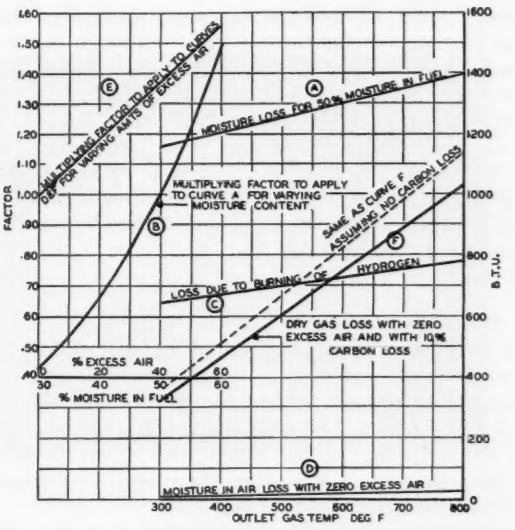

FACTOR
B.T.U.
MULTIPLYING FACTOR TO APPLY TO CURVES E FOR VARYING AMTS OF EXCESS AIR
MOISTURE LOSS FOR 50% MOISTURE IN FUEL
MULTIPLYING FACTOR TO APPLY TO CURVE A FOR VARYING MOISTURE CONTENT
SAME AS CURVE F ASSUMING NO CARBON LOSS
LOSS DUE TO BURNING OF HYDROGEN
DRY GAS LOSS WITH ZERO EXCESS AIR AND WITH 10% CARBON LOSS
% EXCESS AIR
% MOISTURE IN FUEL
MOISTURE IN AIR LOSS WITH ZERO EXCESS AIR
OUTLET GAS TEMP DEG F

CHART FOR CALCULATING PROBABLE BOILER EFFICIENCY FROM FUEL ANALYSIS

C = Hydrogen loss
D = Loss due to moisture in air, assuming 67 deg. F. wet bulb, 72 deg. F. dry bulb. No excess air
F = dry flue gas loss
G = Correction factor for D for excess air
K = Correction factor for F with moisture contents other than 50 per cent
994 = 10 per cent loss due to assumed unconsumed carbon loss, = 730 B.t.u., plus 3 per cent unaccounted for and radiation loss = 264 B.t.u.
8800 = fuel value of 1 lb. of dry fuel

As some may question the assumption of as great as 10 per cent carbon loss in the foregoing computations for efficiency, there is shown in the curve, the dry gas loss that would result in case 100 per cent of the carbon in the fuel was consumed in the furnace. This represents approximately a 10 per cent increase in the dry gas loss. As, in the formula, we deducted 730 B.t.u. for a carbon loss of 10 per cent, we would correspondingly, with a 5 per cent carbon loss, deduct only 365 B.t.u. In this case the dry gas loss would fall approximately midway between the values given on curve F for 10 per cent carbon loss and the supplemental curve shown for zero carbon loss.

As it is desirable to provide a standard to which boiler room operators may work and as most of the data can be supplied from modern boiler room instruments with which to check performance, the author suggests the above method as a means of setting a "bench mark" for performance with hog fuel, against which checks can be made on operating results, daily, weekly, or monthly, to keep the boiler plant tuned up for best results.

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Stopping Vibration in Steam Turbines

Impurities in Steam, Poor Piping Layout and Electrical Defects Most Common Source of Difficulty. By Marin Phillips

VIBRATION in a steam turbine, if allowed to continue, soon becomes a serious matter, due to the high rotating speed. This vibration may be brought about through an out-of-balance rotor or faulty installation or design of the turbine itself, although due to the close attention paid to the construction of the turbine and balancing of the rotor at the manufacturer's works, most vibration will be due to faults that develop while in operation. The satisfactory operation of the turbine is then in the hands of the purchaser by seeing that it is properly installed on a foundation of sufficient weight and strength to prevent vibration in the turbine, due to give or settling.

Causes of Vibration

Rotor may become unbalanced after being in service for a period of time the length of which will depend on the care it receives and the conditions under which it is operated. The unbalancing may be brought about due to unequal wear, the development of some mechanical defect, stripping of the blades, or, if the turbine is driving an electric generator, there may be a displacement of the generator field coils.

Sometimes when a turbine is opened up for inspection or repairs several blades will be found lying in the bottom of the casing. These have been stripped from the rotor while running. The blade stripping may be due to hidden mechanical defects in the blades when installed. Outside of this, the most logical cause is due to water entering the turbine from priming of the boiler. In extreme cases solid impurities in the steam may cause blade stripping, although in most cases this results only in excessive wear of the blades. Impurities in the steam will produce blade vibration by building up a deposit on the blades and passage ways which may eventually close the gap between the stationary and rotating parts, causing them to rub or strike. Boiler feed water should be kept as free from impurities as possible, in order to prevent the steam from carrying them over into the turbine.

Boiler Operation

When water is carried into the turbine from a priming boiler, or other cause, the slugs of water will be traveling at a high velocity along with the steam and will strike the blades with considerable force. Such force may often be of sufficient power to break off a blade which will result in stripping of others. To prevent water getting into the steam going to the turbine, careful firing and proper feedwater treatment, to prevent priming, should be adhered to. Where superheaters are not in use a separator should be installed in the steam main ahead of the turbine. Such a separator will also help to remove impurities in the steam before they reach the turbine.

Turbine vibration may be brought about by loose foundation bolts, a settling of the base or grouting throwing the turbine out of level or line. The shaft or blade wheels may be warped out of line due to unequal expansion on a rush start up or improper warming up preparatory to starting. There is a belief amongst some turbine operators that the throttle valve should be cracked to warm up the turbine slowly before starting it. This will result in unequal expansion of the turbine parts, due to an unequal distribution of steam through the turbine. Best practice dictates that the throttle valve be opened enough to start the turbine turning over slowly and then close off the valve to where the turbine will just keep turning over.

Vibration may be caused through wear on the shaft packing rings. When originally installed the clearance on the rings will be very small. This clearance is increased through wear in operation making it essential that the rings be either taken up or renewed before the wear becomes great enough to cause serious vibration.

Piping

Excessive wear in the coupling between the turbine and its load may also be the source of vibration, or vibration may be transmitted back to the turbine from the load it is driving, especially if a non-flexible coupling is in use. Another possible source of transmitted vibration may result from the intake or exhaust pipe connections to the turbine. It is for this reason that all pipe connections should be flexible and well supported in order to reduce the transmitted vibration to the minimum.

There are several points which, if borne in mind, during the installation of the turbine will go a long way towards making the work easier, resulting in better operation of the unit over a longer period of time. The first requisite is that there must be no strain imposed upon the turbine proper, to cause misalignment. This calls for a careful installation of the steam and exhaust piping. When connecting the turbine to the steam and exhaust lines the piping should begin from the line being connected to, and end at the turbine, the turbine connections to be the last ones made in the line. If this procedure is not followed and the piping is started at the turbine, the weight of the piping will rest directly on the turbine. This extra weight on the turbine may distort the casing or spring it out of line from sheer weight or the force exerted by expansion when put in operation.

Expansion and Support

An expansion joint should be located in the exhaust piping line and connected next to the turbine exhaust flanges, in order to eliminate undue strain set up by expansion. The expansion joint, to be effective, must be light enough to be flexible. When an expansion joint is used the same precaution in connecting up, must be followed.

When piping up a turbine all pipe supports should be made permanent, and do not expect a block of wood under the pipe, or a wire hanger to take the strain

off the turbine. The most common method of supporting the piping is by use of the tie rods from a substantial overhead support and connected to the piping near the turbine. The piping may be supported by an adjustable foot placed under it and as near the turbine as possible. Where tie rods are used to support the piping they should be short, in order to be most satisfactory. Whichever type of support is used it should be put in place before making the piping connection to the turbine.

Where screwed fittings are used, the line should be equipped with swinging joints. If flanged fittings are to be used, long radius ells should be placed in the steam piping line to take care of the expansion of the bends. Care must be taken to see that the flanges are parallel so that it will not be necessary to use force to bring the faces together or to line up the bolt holes. When the piping job is completed and all connections made, except the last one to the turbine, the piping must be well blown out before making this connection in order to remove any foreign material that happens to be in the pipe, to prevent its entering the turbine.

Blade Fatigue

When vibration trouble develops, an investigation may be set up in the blades themselves due to the action of the governor admitting steam periodically, or blade vibration may be due to deposits on them, or in the steam passageways, especially if it interferes with the regular passage of steam. There is a chance for undue fatigue of the blades due to the vibration set up by the governor admitting steam in gusts if the turbine is operated continuously on light load.

Vibration in a turbine driving an electrical generator may be due to an unbalancing caused by some electrical defect in the generator. A magnetic unbalance will be set up in the generator which will cause vibration where the field poles are of unequal strength, or if the air gap between them and the armature becomes unequalized from worn bearings. Other electrical defects which may cause vibration to be transmitted to the turbine are grounds, or short circuits in the armature or field poles and an open circuit in the armature.

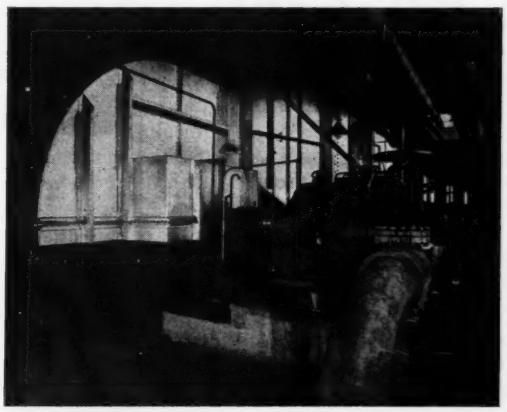
When vibration trouble develops an investigation should be started immediately to determine the cause so that it may be removed at once. This is a precaution against an expensive repair bill sure to develop if the vibration is allowed to continue. Often the investigation will show that the cause of the vibration is a simple one and easily remedied. A steam turbine should be opened up at regular intervals for inspection, repairs and cleaning. An inspection schedule should be developed. The length of time which may elapse between inspections will depend on the operating conditions. Also the condition of the steam, whether wet or superheated and its cleanness.

Employment of some 2500 men on manufacture, sale and installation of General Electric oil furnace and air conditioning products is reported by J. J. Donovan, manager of the air conditioning department. Also increase at the Schenectady, Pittsfield, West Lynn and Fort Wayne schools of instruction for sales and service men has been made and some 1500 men have been employed by dealers, although sales are being limited to 45 cities along the Atlantic seaboard.

High Pressure Plant Saves $1,000 Daily

Fifteen new turbines contribute to the saving of $1000 a day in steam costs, effected by the new steam plant installed in the Pennsylvania Sugar Company, Philadelphia, Pa. These Westinghouse turbines constitute one of the largest single installations of small turbines operating at 150 lb. back pressure in the country.

They receive steam at 400 lb. pressure and 75 deg. F. superheat, and, exhausting at 150 lb., supply steam



ONE OF THE 730-HP., 128-600 R.P.M. WESTINGHOUSE TURBINES DRIVING AN INDUCED DRAFT FAN

for many processes throughout the plant. Three of the turbines, rated at 340 hp. and 2550 r.p.m., drive the boiler feed pumps; eight 100 hp., 860 r.p.m. turbines drive coal pulverizers; two forced-draft fans, of 108,000 c.f.m. each, are driven by 340 hp. turbines; and two induced-draft fans, of 200,000 c.f.m. each, are driven by 730 hp. turbines.

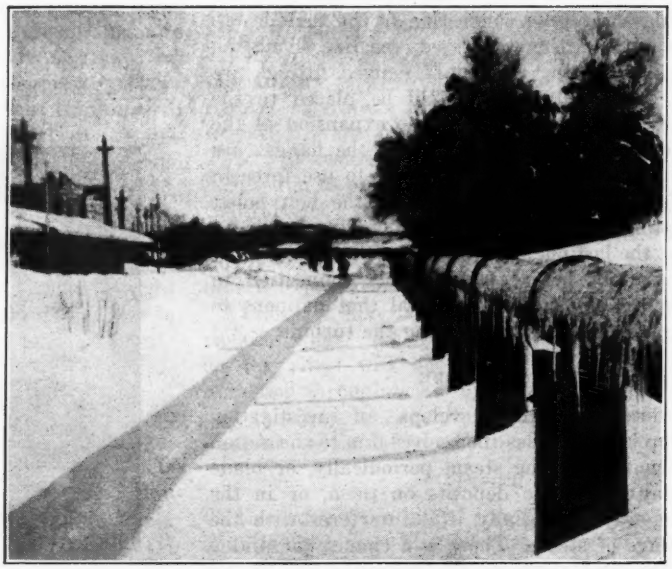
One of the interesting features of the plant is that it can be started without any external source of power. At the difference between its cost of operation and that of the old plant, the new turbine installation is expected to pay for itself in two years.

First place in the fifth national annual accident prevention contest conducted by the National Safety Council among electric companies with more than 500 employes was won by Central Power and Light Co., San Antonio, Tex., the first time an electric company in that part of the United States has won first place. The contest, designed to reduce the number of accidents to hours worked, covered the year ending June 30. During the last 156 days of the contest there was not a single accident to a C. P. & L. employe in the entire South and Southwest Texas territory, some districts having no accidents during the whole year.

L. C. Picnot, safety director, praised the interest of E. B. Neiswanger, president of the company, in safety work. Workmen are provided with every modern safety device that the company can purchase and regular meetings are conducted to train the men in accident prevention. "Winning the award is simply the cumulative effect of long-continued work on the part of the company's entire personnel to carry out fully the accident prevention program of the Bureau of Safety," he stated.

Power Utilization

40 to 90 Per Cent Reduction in THERMAL WASTE Through



1-Mile Steam Line of Bird & Sons, Inc.

Courtesy Keasbey & Mattison Co.

Modern Heat Insulation

By Reginald Trautschold

SERIOUS waste of expensively generated heat is reported to occur in fully 75 per cent of our power and industrial plants. It can be effectively curtailed by suitable insulation so that time after time reduction from 40 to 90 per cent has been consummated with moderate capital investment. In fact, quite often greater opportunities for saving lie in decreasing heat wastage than in increasing efficiency of heat utilization.

Opportunities abound not only in the power plant, where steam lines, boilers and all steam using equipment should be protected, but also in the production plant wherever thermal processes are involved. Illustrative of the high value of heat conservation is the experience of the Delta Star Electric Co., Chicago, Ill., with a galvanizing furnace during night hold-over periods. This furnace, set in a base of insulating materials, had its sides well protected against heat losses and an insulated cover was furnished in the hope that power consumption during the night might be reduced. It was; being cut from an average of 47.4 kw. to 22.2 kw., a reduction of 53 per cent, which represents a yearly saving of $1,749 or net annual return of 460 per cent on the investment.

Outdoor Pipe Line Insulation

Necessity of providing protection for steam lines was strikingly demonstrated by a couple of paper mill installations in New England. The first of these, shown in the headpiece, a line extending from the East Walpole, Mass., plant of Bird & Sons, Inc. to its Norwood plant, delivers the steam equivalent of 10,000 kilowatts at 163 lb. pressure through almost a mile of piping laid in the open, with a heat loss of only 3 per cent, although during the winter months the line is covered with snow and ice and temperature is frequently well below zero. Steam could be generated at an attractive figure at the East Walpole plant, while the cost of steam generated at the considerably smaller and less efficient Norwood boiler house was about twice as high. It was hoped that a saving might be made by piping steam from the more efficient plant to the Norwood mill, despite the fact that the investment in the shut down Norwood boiler plant would still impose carrying charges amounting to some 20 cents per 1000 lb. of steam demand at Norwood, in addition to the overhead on investment for the pipe line connecting the two plants.

Line Data and Results

It took considerable courage to embark on this venture but the results well justified the undertaking. Despite the charge imposed by the shut-down boiler house, an actual net saving of approximately 15 cents per 1000 lb. of steam was realized.

This line is standard weight 8-in. steel pipe, 4550 ft. in length. Resistance due to bends, valves and fittings makes the equivalent length 4839 ft. Two layers of

molded, sectional, 85 per cent magnesia pipe covering, with joints staggered in alternate layers, and an outer wrapping of hair felt provide the protection against heat losses, while two thicknesses of roofing paper furnish protection against the weather.

During an 8-hr. test, conducted while the average outside temperature was 25 deg. F., steam supplied at the East Walpole end at 163-lb., 99.15 per cent dry, was delivered at the Norwood plant 96.52 per cent dry and at a pressure of 133 lb. Thermal loss in the latent heat of steam and that carried away by the condensation averaged 97,124 B.t.u. per hour, total heat at the East Walpole and Norwood ends respectively averaging 36,720,243 and 35,733,119 B.t.u. per hour. Line loss, consequently, amounted to only 2.69 per cent.

Steam, Then Electric Generation Concentrated

Another noteworthy installation was made between Mills No. 4 and No. 1 of the Fitchburg Paper Co., Fitchburg, Mass., where an 8-in. line, somewhat over 1000 ft. in length and protected against heat losses in an exactly similar manner, connects the two mills. This line was installed about 6 yr. ago to supply Mill No. 1 with steam at 150-lb. pressure, generated in the power plant of Mill No. 4, the boiler house at No. 1 being shut down. This steam was used in two reciprocating engines driving generators to furnish current for Mill No. 1 and exhausting at 12 lb. to supply process steam. The yearly saving in labor and fuel expenses by closing down the boiler room of Mill No. 1 returned never less than 50 per cent on the investment.

Going a step further it was found that 17,000 lb. of 12-lb. steam required per hour by Mill No. 1 for process operations could be furnished even more economically via the 8-in. insulated pipe line. Consequently, an efficient steam turbine-generator set operating at a back pressure of 25 lb. was installed at Mill No. 4 and part of the exhaust was carried to Mill No. 1.

As current output of this turbine-generator set met the requirements of both mills, the two reciprocating engines at No. 1 were discarded with a considerable saving in current cost. In fact, the net saving effected by this remodeling of the steam and current distributions netted 40 per cent return annually on the entire investment entailed, a yield attributable in its entirety to the efficacy of modern pipe covering insulation.

Large Indoor Temperature Differences

Ordinarily steam lines are within buildings and not exposed to the severe atmospheric conditions of New England winters. But radiation losses mount rapidly with rise in initial steam temperature and may, consequently, be as serious with indoor modern high-temperature and pressure lines as for outdoor piping, conveying steam at relatively low temperature.

Temperature difference between the steam and the outside atmosphere at East Walpole is at times 400 deg. or more, yet the thermal losses are held around 3 per cent. A 400-deg. difference inside a boiler house would mean saturated steam supply at a pressure of 450 lb., and holding thermal losses down to considerably less than 3 per cent should present little difficulty, even with the higher temperatures and pressures now used, since insulating materials to resist the deteriorating effects of even the highest temperatures developed in our most advanced high-pressure steam plants are now available.

Boiler Insulation

Wherever large temperature difference is involved, high thermal insulation is indicated. Globular rotary boilers used extensively for bleaching in certain thermal processes, such as that of paper making, are an example. The standard boiler of this type is 14 ft. diam. and has approximately 585 sq. ft. of exposed surface. The charge to be cooked is packed into the boiler, the cooking liquid added and the cooking process consummated by use of direct steam, ordinarily at a temperature of about 287 deg., the surrounding atmosphere being held preferably at about 70 deg.

This gives a temperature difference of 217 deg. and the heat loss from an uninsulated boiler amounts to 597 B.t.u. per sq. ft. per hr. A 2-in. coating of suitable insulating material over the exposed boiler surface cuts the heat loss to 57 B.t.u. per sq. ft. per hr., thus saving virtually 90 per cent of the heat otherwise wasted.[1] Total cost of insulating the boiler to realize this saving would amount to about $450. Placing a valuation on the steam saved of 50 cents per 1000 lb., a daily cook with the insulated boiler would cost at least $375 less a year than with an uninsulated boiler. Allowing for all carrying charges, net yearly saving in the expense of boiler operation would give a net yearly return of 58 per cent on the investment involved.

Another instance is the experience of the White Swan Laundry at Anderson, Inc., where exposed surface of a 100-hp. Scotch marine boiler was covered with 1½ in. of monolithic insulating cement. Records extending over a year show that the resulting saving in coal consumption by the insulation of the boiler amounted to 600 lb. a day, or some 90 t. during a normal year.[2] At the same time, the capacity of the boiler was noticeably increased and working conditions for the fireman greatly improved. These gains can doubtless be duplicated in many small boiler plants.

Roof Insulation

Insulation of buildings, particularly the roofs, against the loss of building heat is decidedly worthwhile, especially in sections of the country where low winter temperatures prevail. Heat losses through the walls of substantially built plants, unless there is an excessive area of window surface, are likely to be much less serious than those through the roofs, also roof condensation, or sweating, may be responsible for heavy losses in plants of some of the process industries.

As example of savings accruing, at the New Haven Pulp and Board Co.'s plant, the roof was a substantial affair, 4-in. thick but every autumn and winter the mill was faced with a serious problem, as not only would roof drippings discolor and injure the quality of the paper produced, but condensation from the warm, humid atmosphere of the mill in contact with the cold roof increased the thermal conductivity of the roof and caused excessive heat leakage. So serious was this that a hot blower system was required to hold the temperature under the roof above the dew point of the humid air, while the dry end of the paper machine had to be provided with a felt canopy to protect the paper against spoilage. Even with these precautions, roof condensation was so marked that the structure rotted and a new roof was required after only 9 yr. of service.

In the hope of overcoming roof condensation, a more

[1]Data furnished by Johns-Manville Corp.
[2]Data furnished by General Insulating & Manufacturing Co.

costly cork-insulated tile roof was built and the troubles ceased. Not only roof drippings stopped so that the canopy over the dry end of the machine could be dispensed with, but conditions over the wet end of the paper machine also improved, building heat was conserved and a substantial saving realized in the amount of coal burned.

In a New England mill having a 4-in. concrete roof of 14,000 sq. ft. area, insulation with 1½-in. corkboard, reduced heat loss through the roof, during a heating season of 210 days of 35-deg. average outdoor temperature, from more than 2,000,000,000 to less than 430,000,000 B.t.u., effecting a saving of about 88 t. of high grade coal during the heating season.

If these economies resulting from proper roof insulation be added to the more-generally appreciated gains from protective pipe covering and those to be realized from correct insulation of boilers, breechings, stacks and all the rest of the equipment in power plant and production departments of mills and factories, the total presents quite a formidable sum, much of which can be saved today in 75 per cent of our industrial establishments and some part in all.

Wherever temperature conditions are uncomfortable due to heat dissipated in an industrial plant, opportunity is almost certain for saving money and cutting production costs by modern methods of heat insulation.

Stuffing Boxes Packed Under Pressure

Lubricated Packing Forced Around Slip Joint Cylinders with Pressure Maintained on the Joint

FOR ITS Yarway, cylinder-guided, all steel expansion joint, Yarnall-Waring Co., Mermaid St., Philadelphia, Pa., has developed a special type of gland, designed to pack the stuffing box while the joint is under full pressure by use of plastic packing. Figure 1 shows a double-ended sleeve joint cut away to show details of the action.

Plastic packing is put into two or more cylindrical chambers in each gland, having stainless steel screw plungers which force the packing through channels into the stuffing box, flow being as indicated by the arrows; this is in the same direction around the sleeve from all pockets, due to deflecting vanes shown in Figs. 2 and 3. The number of packing chambers depends on the diameter of the glands.

Packing material is a special combination of long-fibre asbestos with inert material in which high-fire-test mineral oil is stored. It is made up in pellets to fit the cylindrical chambers and can have the lubricant oil replenished through the pressure lubricators shown in Fig. 1.

Packing chambers can be recharged and additional

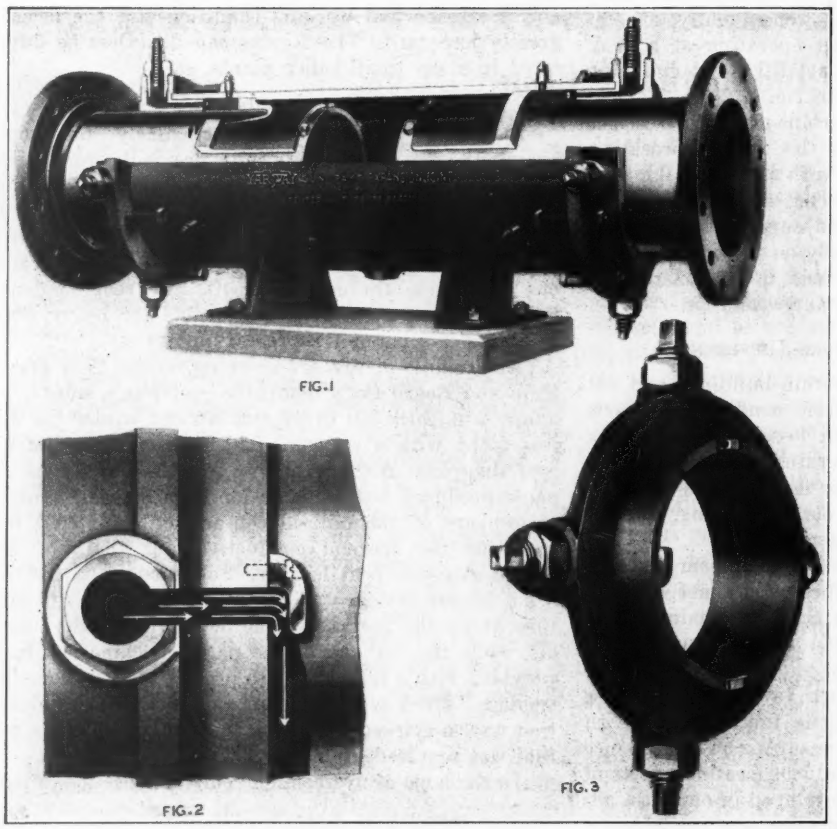


FIG. 1. GUN-PAKT JOINT WITH ALEMITE LUBRICATION

FIG. 2. PLASTIC PACKING IS FORCED TO FLOW INTO THE STUFFING BOX

FIG. 3. FLOW OF PACKING FROM GLAND CHANNELS IS DIRECTED BY DEFLECTOR VANES

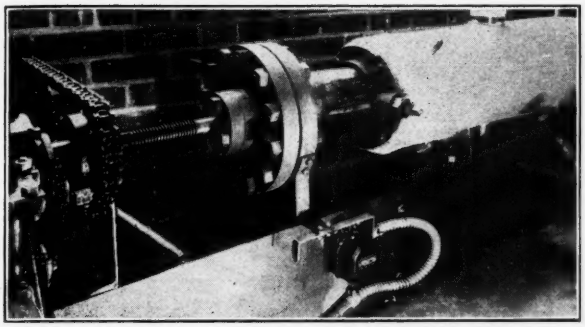


FIG. 4. REVERSING MOTOR DRIVE GIVES TEST OF YEARS OF EXPANSION AND CONTRACTION ACTION IN A SHORT TIME

packing forced into the stuffing box with pressure on the joint, since the deflectors act as check valves to prevent flow-back of packing. The equipment is intended for use with pressures from sub-atmospheric to the highest used in modern steam-heating practice.

As stuffing box leakages are likely to start when a system is under maximum load and at times when closing down to repack would involve difficulty and annoyance, the desirability of repacking or replenishing without shutting off pressure can readily be appreciated. It is believed that application to reciprocating rods or rotating shafts will be found as feasible as use for expansion joint sleeves.

Figure 4 shows a test of this gland, which has been given the trade name Gun-Pakt, made on a double-ended, all-wrought steel welded expansion joint. The two ends of the joint were connected by a threaded central bar, rigidly bolted to the blank end flanges. By this means, sleeves were moved back and forth 8 in. slowly, by reversing a motor every 3 min. through a switch shown at the front below the gland. Expansion and contraction movement that would occur during 20 yr. life of a joint was thus reproduced over the period of 6 mo. during which the test has been operating.

Possibilities of the application of this system to packing stuffing boxes on rods, shafts and piping are apparently unlimited.

Electric-Driven Dredge

WITH almost universal availability of electric power, portable machinery, heretofore of necessity driven by independent prime movers, can now often be driven by motors from power lines. An example is the suction dredge Middlesex, shown herewith engaged in deepening the Charles River, Boston, Mass. Originally operated by steam, this still retains one oil-burning boiler for heating purposes and for supplying a double horizontal reciprocating steam engine to operate the winding machinery.

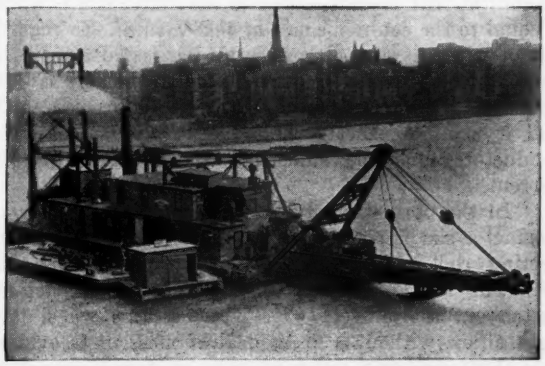


FIG. 1. ELECTRIC-DRIVEN DREDGE MIDDLESEX SHOWING LADDER WITH CUTTER AT END, FLOAT SUPPORT AND MOTOR DRIVE

Cutter head and dredge pump are now operated by electric motors, using outside current. The dredge pump has a 17-in. suction, a 15-in. discharge and requires a 500-hp., variable-speed motor of 500 r.p.m. maximum speed. For the cutter head, which runs at a maximum speed of 25 r.p.m., a 300-hp., variable-speed motor of 1750 r.p.m. maximum speed is used, necessitating speed reducers between the motor shaft and the main shaft upon which the cutter head is mounted. This reduction is made in two steps, the first a De Laval worm gear of 13¼ to 1 ratio, installed on the ladder of the dredge. To follow the ladder at various angles, from horizontal up to inclination of 45 deg., forced feed lubrication is used, consisting of a gear pump at one end of the worm shaft, which draws oil from the bottom of the case and

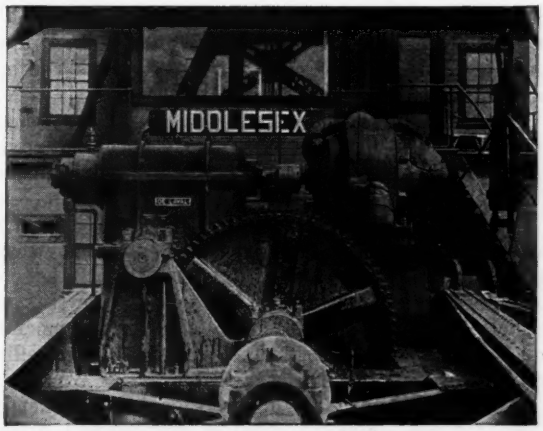


FIG. 2. SPEED REDUCTION BY WORM GEAR, PINION AND GEAR, MOUNTED NEAR BASE OF LADDER.

delivers it to the plain sleeve bearings of the worm gear shafts, to the worm and gear tooth surfaces, and the Kingsbury worm thrust bearing. For second reduction, a gear-shaft pinion engages with a cast steel, cut tooth, spur gear enclosed in a water-tight casing and running in oil.

To support the motor, the worm drive and the bearing stands both fore and aft of the spur gears, the bedplate is of welded construction, slipped between and riveted and welded to the side girders of the ladder. With the cutter machinery, the ladder measures 60 ft. 8 in. from the hinge pin to the end of the cutter. It is partly supported when in the water by a pontoon tank which is secured to the under side of the ladder hinges and stands with its top approximately at water level when the cutter machinery is in a horizontal position.

LOSS OF LIQUID through small leaks at joints mounts up in a most astonishing way. It has been estimated, as shown in Oxy-Acetylene Tips, that one drop per second will total 396 gal. a year, a small stream breaking into drops 3240 gal. a year and a 1/16-in. stream 26,640 gal. a year. At a cost of even 2 c. a gallon for liquid and pumping, evidently prevention or remedy of leakage will pay good returns. With welded joints the probability of leakage is so small as to be negligible.

POWER PLANT ENGINEERING December 1932

This thing called POWER FACTOR——

Part III. Effect of mass in a mechanical oscillating system. Phase displacement in mechanical systems. Effect of elasticity. Interchange of kinetic and potential energy. Mechanical power factor correction.

HELLO, CHIEF, HOW was the party over in Newark last night? I just met Elmer at the office and he seemed to be somewhat under the weather. Well, I warned you birds——"

"Warned us," retorted the chief, interrupting Val's insinuating remarks. "You're a fine one to take it upon yourself to issue warnings—what do you think you are, the weather bureau?"

"Tut, tut, tut, be careful of your blood pressure, old timer. Can't a fellow offer some good moral advice without being insulted? But that is all one can expect of an engineer I suppose; now take the chemists——"

"Yes, take the chemists," rejoined the chief sarcastically, "take them for a ride, take them anywhere, but don't let 'em run around loose. Of all the confounded nuisances on earth, you test tube artists are the worst. Here it isn't even 9 o'clock in the morning and I suppose you expect me to waste my time telling you short stories about power factor."

"Righto, professor, righto," exclaimed the chemist, "how did you guess it? That is just what I expect.

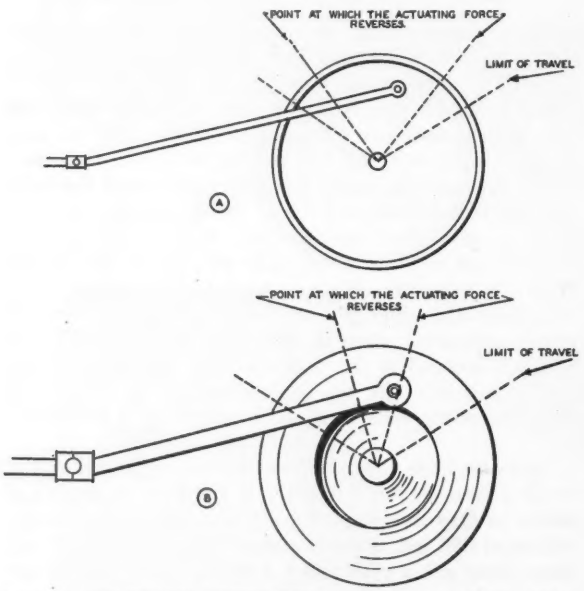
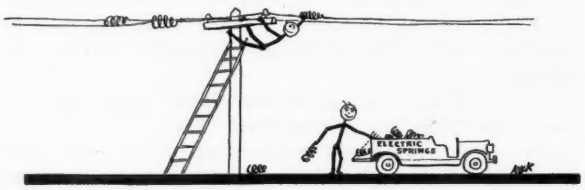


FIG. 1. DIAGRAMS REPRESENTING OSCILLATING FLYWHEELS DRIVEN BY CONNECTING RODS

The angle between the point at which the actuating force reverses and that which indicates the limit of travel, it will be noted, is much greater in the case of a heavy wheel than with a light wheel.

While you were carousing around Newark last night, I burned the midnight oil, studying about induction components and counter e.m.f.'s. I went home last night thinking I knew all about power factor, but after thinking it over, I still don't know what to do about it."

"What don't you know?" asked the chief. "Don't you understand what I told you yesterday?"



Yes, you can put springs in electric circuits

"Yes, I got all that, but I want to know what it means in the circuit. Does this current which flows in the circuit at the time the impressed voltage is zero, produce heating, just like any other current?"

"Yes, of course, and if you were anything but a chemist you would see that without my explaining it. However, I suppose I'm the goat, so listen.

"Current is current, regardless of when or where it appears in the circuit and whenever there is current there is heating. Get that in your head. If you will look at the diagram I drew the other day (Fig. 3, Part II)* you will note that insofar as the impressed terminal voltage is concerned, at the time the latter is passing through zero, no voltage is acting on the circuit; the current at that instant is due to the active e.m.f. which is equal to the counter e.m.f. *at that instant.* So regardless of whether or not there is an impressed e.m.f., the current which flows (due to the active e.m.f.) is just as real as if it were maintained by the impressed e.m.f. and it exhibits exactly the same heating effect. The conductors must be sufficiently large to carry this current.

"In the oscillating flywheel analogy, this factor of conductor size is comparable to the strength of the connecting rod and driving system through which the actuating force is applied to the wheel. Here, let me sketch out a flywheel (Fig. 1A). If this wheel is a light affair, without a great deal of mass, it is evident that the connecting rod need only be strong enough to overcome the friction at the bearings or to carry what-

*Page 767, November issue.

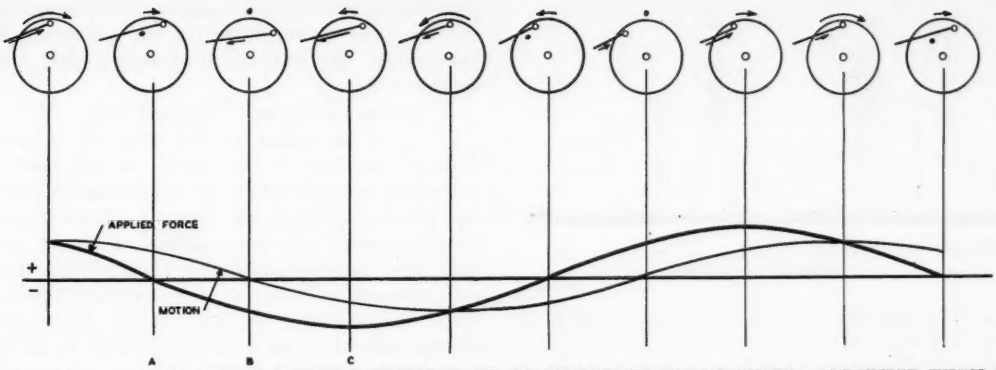


FIG. 2. DIAGRAMS SHOWING SUCCESSIVE POSITIONS OF AN OSCILLATING FLYWHEEL, TOGETHER WITH CURVES REPRESENTING APPLIED FORCE, AND WHEEL VELOCITY

ever load might be connected to the shaft. This represents an a.c. current with negligible inductance, that is, high power factor.

"If the wheel is a massive one, however, as in Fig. 1B, the connecting rod must be made considerably stronger than in the first instance, for not only must it transmit enough energy to overcome the normal friction and the steady load but also to overcome the inertia of the wheel at each reversal. The greater the mass of the flywheel, the greater will be the force required to bring it to rest before reversal and to accelerate it after reversal. So, you see, the greater the mass of the flywheel, the stronger must be the connecting rod, although the useful work done will be no greater than in the case of a light wheel."

"Well, why use a heavy wheel, then,—why not dispense with the wheel altogether?" asked Val.

"That is not always possible. After all it is not necessarily the wheel that is involved, but the mass of the whole moving system and that cannot be eliminated entirely. If the useful load is of appreciable magnitude, the size of the parts must be made sufficiently massive to transmit this load and this mass alone introduces the reactive forces we have been discussing."

"What's the point of all this discussion, then——"

"Now, wait a minute, don't get impatient, we'll get to that. I merely want to stress the fact that we cannot eliminate mass from a mechanical system. But don't let that discourage you, because even though we cannot eliminate mass, we can counteract its effect by various means.

"Before I go into that, however, I want to explain more clearly what actually happens in the case of the flywheel in this diagram (Fig. 1). As I explained, the greater the mass of the wheel, the greater will be the force required to bring the wheel to rest at the end of the stroke and accelerate it in the reverse direction. Now, in order to stop the wheel and reverse it at the end of each stroke, what must I do?"

Val scratched his brow and looked puzzled.

"Why," he began, not knowing what to say.

"It's easy to see you're only a dumb chemist," said the chief with feigned disdain. "Well, I'll tell you. In order to stop the wheel *it is necessary to reverse the force acting on the connecting rod, some time in advance of the actual reversal of motion of the wheel.*"

"Oh, of course, I could have told you that," exclaimed Val rather sheepishly. "I see that——"

"All right, that's fine," said the chief. "Just see that you don't forget it, because it is quite important. At certain points during the stroke, then, the applied force is actually acting in opposition to the motion of the wheel. Now what does this mean? No, don't tell me, I'll explain.

"It means, simply this, that the driving force is *out of phase* with the motion of the wheel in just exactly the same way that the electromotive force in an electrical circuit can be out of phase with the current. Do you see that?"

"Yes," replied the chemist, "I think I do."

"Here," said the engineer, still doubtful of Val's understanding, "let me have that pad of paper, perhaps I can explain it better by means of a series of diagrams like this."

For several minutes he busied himself drawing the diagram shown in Fig. 2. Then he continued.

"Here I have drawn a series of diagrams showing successive positions of the flywheel, and below them I have shown two curves, one representing the applied force and the other the actual motion of the wheels. If you will look at this closely, you will note that at the time the applied force passes through zero, the wheel still has considerable velocity towards the right. This condition is shown at A. In these diagrams the length of little arrows shown at the top of the wheel and parallel to the connecting rod, represent the magnitude

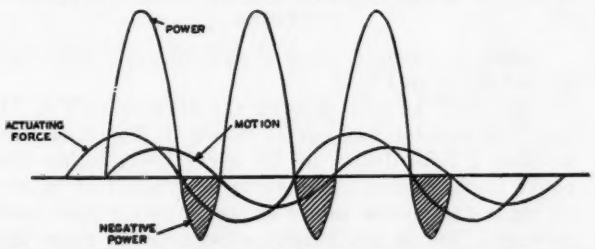
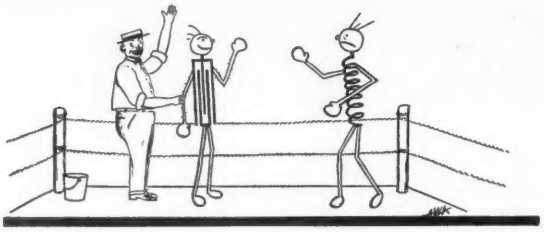


FIG. 3. CURVES SHOWING ACTUATING FORCE, VELOCITY (OR MOTION) AND POWER IN THE OSCILLATING FLYWHEEL SYSTEM

as well as the direction of the motion and applied force respectively. At the point B the wheel has come to rest, but by this time the applied force has increased to a considerable value in a negative direction. At C, the wheel is accelerating in the negative direction, and the applied force has reached maximum value in the negative direction. (In this, of course, negative means towards the left and positive, toward the right.)

"And so on. You can readily see, now, what I mean



when I say the applied force is out of phase with the motion. Is this clear now?"

"Perfectly, old-timer. That sure is a clever way of explaining it. The motion always lags behind the applied force, and the greater the mass of the wheel the greater will this lag be. Is that right?"

"Yes, and the greater will have to be the strength of the connecting rod, assuming a constant period and amplitude of oscillation. You see, at the end of the stroke, when the direction of motion is in opposition to the applied force, the wheel is trying to pull the connecting rod. It is trying to give back the energy which was used in accelerating it originally and if permitted to it could do useful work. As it is, no useful work is done and we must expend additional energy in exerting a braking effect."

"Do you mean to tell me, that during this portion of the stroke, the wheel is trying to give back power to the system that set it in motion?" asked Val.

"Yes, precisely," replied the engineer. "During that portion of the stroke the energy associated with the system acts in a reverse direction. I can show this better by means of a diagram."

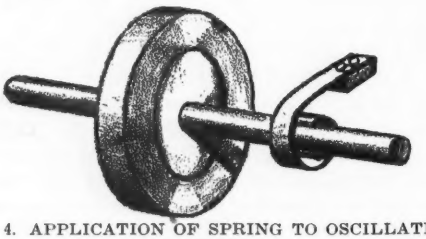


FIG. 4. APPLICATION OF SPRING TO OSCILLATING FLYWHEEL

Again the engineer drew a wave diagram, this time the one shown in Fig. 3.

"In this," he said, showing the drawing to Val, "I have redrawn the two curves shown in Fig. 2 and in addition I have drawn in the curve representing the power in the system. This curve is obtained by multiplying instantaneous values of the actuating force and velocity. This is not strictly accurate, but since the 'motion' really represents the energy in the flywheel, we may draw the power curve in this manner. As you will note, at times where the motion is positive and the actuating force negative, the power is negative. This you probably know is so because the product of a positive and a negative quantity is negative. In the same way, the product of two negative quantities is *positive*. Therefore, at the time when both the actuating force and the motion of the wheel are negative, the power is positive. Understand?"

"Yes, that's very clear," said Val.

"All right, then," continued the engineer. "Now, the problem is, to reduce the angle of displacement between the two curves representing the actuating force and the motion. We want them to be *in phase*. How can we do that?"

"You're asking me?" queried Val.

"No, I am going to tell you. It is very simple. Toward the end of the stroke, at the time when the actuating force is acting in opposition to the motion of the wheel, I pointed out that the wheel is possessed of kinetic energy which is capable of doing work. Suppose, now, we could devise an arrangement whereby this energy could be stored as potential energy which in turn could be expended in accelerating the wheel in the reverse direction, we would come close to accomplishing our object, wouldn't we?"

"It looks that way," assented Val, timidly, "but how could you do that?"

"In this way. Suppose, that instead of merely carrying the flywheel shaft in a set of bearings we attach a heavy spring to the shaft as shown in Fig. 4. The spring, you see, will permit the wheel to revolve a certain limited amount in each direction. As the wheel moves against the action of the spring, however, energy will be stored up in the spring, which when the wheel reverses will be returned to the moving system.

"Now, what happens as the connecting rod moves back and forth? See these diagrams? (Fig. 5). Assume that the wheel starts from rest at the center of the stroke, as shown at (a). As the wheel starts to move we not only have to supply energy to carry the load and to overcome the inertia of the system but also to compress the spring. When the wheel reaches the point x, as shown at (b) the actuating force is cut off, as already explained, but instead of applying a force in the reverse direction, as was necessary before the spring was introduced, now the resistance offered by the spring

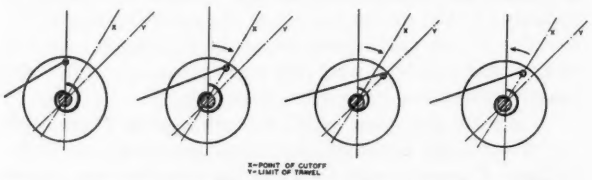


FIG. 5. ACTION OF SPRING UPON OPERATION OF OSCILLATING FLYWHEEL

is sufficient to bring the wheel to rest in the interval between x and y.

"At the point y [Fig. 5 (c)] the wheel comes to rest but the spring is now fully compressed and has stored in it considerable *potential* energy which tends to rotate the wheel in the reverse direction. The wheel, therefore, reverses under the energy stored in the spring. When the point x is reached on the return stroke most of the potential energy in the spring will have been returned to the system where it manifests itself as inertia. At the point x (Fig. 5 d) the actuating force is again applied through the connecting rod in the opposite direction and the sequence of events is repeated at the other end of the stroke. Do you see?"

"Do I see?" repeated Val. "By George, chief, now I'm beginning to see what you're driving at. You're not so dumb after all. With the spring, in the system as you have drawn it, you can reduce the size of the connecting rod, isn't that it?"

"Exactly, that's just it. By introducing the spring

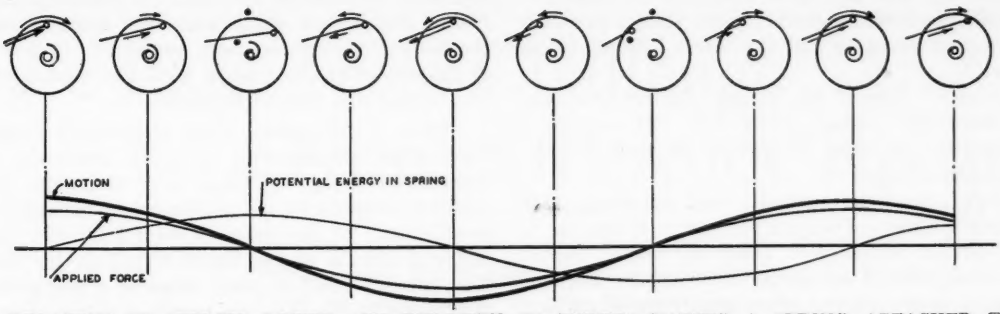


FIG. 6. RELATION OF APPLIED POWER AND VELOCITY IN SYSTEM HAVING A SPRING ATTACHED TO OSCILLATING FLYWHEEL

we let the inertia (due to the mass of the wheel) act against the force produced by the spring so that the only work the driving rod has to overcome is the useful load, whatever that may be. In other words, by properly proportioning its spring we can raise the *power factor* of the system to unity."

"Power factor?" questioned Val. "What do you mean?"

"Just what I said. The displacement between the actuating force and the motion of the wheel in the example where no spring was used represents the power factor of the system. Here, in this diagram (Fig. 6) I have drawn a series of diagrams showing successive positions of the wheel, as I did before (Fig. 2), but in this case I show the effect of the spring. Below, I have drawn the applied force and "velocity" curves.

"As you can see, for a time a steady force is applied to the connecting rod causing the wheel to turn. At the point A the velocity of the wheel is a maximum, but as the wheel proceeds from A to B, the velocity decreases because an 'increasing' amount of the energy delivered to the wheel is spent in compressing the spring. The potential energy in the spring, however, rises. At B, the applied force is cut off sharply, but the wheel still has considerable kinetic energy and so it continues even though the applied force has been removed. The wheel, however, is still acting against the spring—compressing it, so the kinetic energy of the wheel is gradually transformed into potential energy in the spring. At the point C the wheel comes to rest and nearly all the kinetic energy formerly vested in the moving wheel is now stored as potential energy in the spring. The spring, therefore, starts to move the wheel in the reverse direction and the potential energy again is converted to kinetic energy. The wheel gradually accelerates. At the point D the applied force again is applied, this time in a reverse direction. And so the cycle is repeated.

"You will note, I have also drawn in this curve representing the potential energy stored in the spring. This, you will see, is 90 degrees removed from the velocity curve, that is, the velocity of the wheel (which represents kinetic energy) is always a maximum when the potental energy of the spring is zero and vice versa,"

"Clear as a bell, old top," exclaimed Val. "I see it all now."

"But do you?" asked the chief. "What do you see?"

"Why, that there is a continual interchange of energy between the wheel and the spring, isn't that right?"

"Yes, but that's not all. There is something even more important. If you will examine the curves closely you will see that the applied energy curve is symmetrical with the velocity curve. In other words, the applied force is now *in phase* with the motion of the wheel. But perhaps I can make this even more clear. Here, let me have that pad of paper again."

This time the chief drew the diagrams shown in Fig. 7.

"In this diagram, I have shown practically the same conditions shown in Fig. 6, except that in this case, the power is applied, not intermittently, but continuously in accordance with a simple harmonic variation. In this case, the applied force curve is exactly in phase with the velocity curve. We have raised the power factor of the system to unity. See?"

"Simple as two and two."

"All right. Now keep all this well in mind for I am going to show you that these very same principles can be applied in dealing with an electrical circuit."

"You mean you can put a spring in an electrical cir

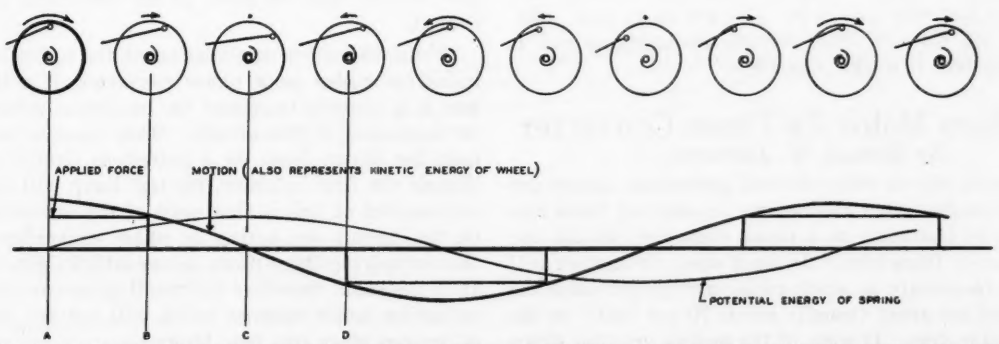


FIG. 7. IN THIS DIAGRAM THE APPLIED FORCE CURVE IS SHOWN TO BE IN PHASE WITH THE VELOCITY CURVE

cuit and thereby raise the power factor of the system?"

The chief engineer laughed. "Sure, didn't you ever notice how they used to coil the wires leading to an electric bell?"

"Oh yeah?" sneered the young chemist, realizing that the chief was poking fun at him. "I may be a chemist, but if you think I'm going to swallow that, you're mistaken—say——"

"All right, don't get excited," said the chief, "I'll answer your queston. Yes, you can put a spring in an electrical circuit which will raise the power factor. Now, of course, when I say spring I don't mean a spring physically—I mean you can place something in an electrical circuit which has an effect analogous to that of the spring in the mechanical system. In an electrical circuit our spring is called a condenser. In other words, we introduce 'capacity' to counteract inductance. Understand?"

"I guess so."

"Well, I don't think you do, so I'll elaborate. In comparing electrical systems with mechanical systems, it has been found that all properties of one system can be expressed in terms of the other. For instance, not only has mass its counterpart in an electric circuit (inductance) but all other properties of a mechanical system can be represented electrically.

"Thus, we can make a table and list corresponding properties in electricity and mechanics in this manner:

In Mechanical Systems		In Electrical Systems
Force (dynes)	=	E. M. F. (Volts)
Velocity (cm/sec)	=	Current (amp.)
Displacement (cm)	=	Charge (coulombs)
Impedance (dyne-sec/cm)	=	Impedance (ohms)
Mass (grams)	=	Inductance (henrys)
Compliance (cm/dyne)	=	Capacity (farads)
Resistance (dyn-sec/cm)	=	Resistance (ohms)

"Now, of course, I do not expect you to remember all these relations—it is not necessary, but I do want you to keep in mind that inductance is analogous to mass and that capacity is analogous to compliance (elasticity)."

"I see," said Val, looking at the table the chief had drawn. "That is why Ed, the electrician, was talking about installing condensers on my motor circuits, is that it?"

"Yes, that's the reason. By means of a condenser properly designed, and properly placed, of course, it is possible to neutralize or at least counteract to some extent, the effect of the natural inductance of the circuit. However, we're getting ahead of our story. I haven't time now, but in our next discussion I will try to explain just why this is so. I've got to go now. Bill is trying out his new draft control this morning and I want to see how it works. Good-bye."

Induction Motor As Phase Converter

By Edward W. Johnston

In many plants where several polyphase motors are operated on the same feeder, one or more of these motors may be operating as a phase converter, should one of the feeder fuses blow. In such case, the motors will continue to operate as single-phase motors provided the load is not too great (usually about 70 per cent) on the individual motors. If some of the motors are shut down and some continue to operate, it is generally possible to restart the motors which were shut down, even though the feeder fuse has not been replaced. If, however, all of the motors are shut down, none can be restarted until the burned out fuse is replaced.

When a three-phase motor is operated single phase, three-phase voltages exist across its terminals, since the counter e.m.f. in each phase of a polyphase induction motor is induced by the rotating field cutting the stator conductors. If the stator is wound for two phase, the induced e.m.f's. at the stator terminals are two phase. The induced e.m.f. in each phase of a polyphase induction motor is less than the terminal voltage (per phase) by the amount of the stator impedance drop. A single-phase induction motor develops a field in quadrature, which combined with the stator field produces a rotating magnetic field.

This rotating field is constant in magnitude at synchronous speed, except for the leakage reactance and resistance drops in the rotor windings. Below synchronous speed, the magnitude of the rotating field varies during a cycle, due to the decrease in the quadrature field produced by the slip.

When, therefore, a single-phase voltage is applied to one phase of a two-phase or a three-phase motor, the rotating field is almost identical with that which exists when polyphase voltages are applied to the terminals. As a result, if a single-phase voltage be applied across one phase of a three-phase stator, the voltages across the three terminals will be nearly equal and will be approximately 120 deg. apart. Since the induced e.m.f's. are less than the applied terminal voltages by the amount of the stator impedance drop and, as the rotating field is somewhat elliptical, the terminal voltages will be somewhat unbalanced. For instance, in the case of a three-phase motor, if the impressed voltage across one phase of a three-phase stator is 220 v., the voltage existing across the other two phases will be approximately 200 and 210 v.

When single-phase power is transformed to three-phase power, the power for two of the phases must be transformed from the initial single phase by the converter. Two thirds of the total power for the three-phase system must be transformed. The other third comes directly without transformation from the single-phase line supplying the converter. The capacity of the converter therefore must be two-thirds as great as the amount of polyphase power delivered.

If the transformation is made from single-phase to two-phase, only half the power on the two-phase side is obtained by actual transformation and the capacity need be only half as great as the two-phase power delivered.

From the above explanation of the operation of the induction motor as a phase converter, it will be seen how it is possible to restart the motors as referred to in the beginning of this article. Many times an electrician tests for blown fuses on a polyphase circuit and, even though the fuse is blown, his test lamp will light. The explanation of this is that some of the induction motors on the circuit are acting as phase converters and are thus supplying three-phase power which lights the lamp. It is desirable therefore to install protective devices on induction motor circuits which will cut the motors out of service when one fuse blows.

Eagle Pass Tests Challenge Hydro Efficiency Records*

Turbines at the Eagle Pass Station at Eagle Pass, Texas, Show Efficiencies of 93.8 Per Cent as Determined by the Gibson Test. Overall Efficiency of Units 90.7 Per Cent.

By L. F. HARZA and ERIK FLOOR.

IN THE AUGUST 1 NUMBER of this publication there was presented a detailed description of the Eagle Pass Hydroelectric Development of the Central Power and Light Co. at Eagle Pass, Texas. Although this plant had been tested in April, at the time this article was published the test results had not been developed. Since that time, however, the test data has been compiled and the efficiencies computed. It is the purpose of this article to present these test results.

Phenomenal improvements in hydroelectric station efficiencies cannot be expected today because the efficiencies are already too near the limit of perfection to permit of further great increase. At the same time because of the size of the units, a per cent or two often means much to the income of an operating company. Thus, though the increase in efficiency is not great in point of numbers, it is our belief that the test results obtained at this station have set up a new mark to shoot at in hydroelectric efficiencies—at least for stations and units of comparable size.

Station Equipment

The station, as may be recalled from the article in the August 1 issue, comprises three turbine units at the end of an irrigation diversion from the Rio Grande River and returning water to the Rio Grande about ten miles above Eagle Pass. Each of the units has a normal rating of 4000 kv-a. for the generator and 4500 hp. under 81 ft. head for the turbine. The units are of the lap-riveted steel plate scroll case, vertical shaft type, set over elbow draft tubes built in concrete. They are equipped with Francis runners having a specific speed of 64.

The plant was tested in April by the Gibson method with E. B. Strowger of the Norman Gibson office in charge. In the accompanying curves the results are set up for comparison with test results of other stations and turbine units in places where units are of comparable size. Information is invited with reference to other tests showing equal or better efficiencies.

Test Results

In the following tabulation are shown the efficiencies obtained by the Gibson Test, both for the hydraulic turbines and for the units as a whole from water level in the forebay to switchboard energy, both at points of best efficiency and at half load points.

Unit No.	Turbine Efficiencies		Overall Efficiency of Unit	
	Best Point	Half Load	Best Point	Half Load
1	93.8	86.6	90.5	82.8
2	92.7	85.8	89.7	82.4
3	93.9	89.0	90.7	85.0

As shown by the profile of the penstock in Fig. 1 conditions were ideal for obtaining accuracy by the Gibson Test, there being available a straight length of penstock between the differential taps for the pressure time diagrams of about 120 ft.

It will be noted from the test results that Unit No. 3 is slightly better than Unit No. 1 and considerably better than Unit No. 2. A satisfactory explanation is not avail-

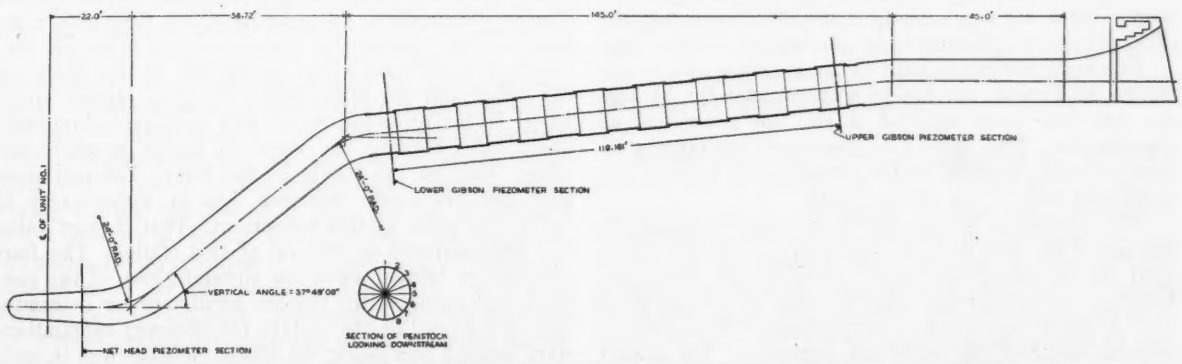


FIG. 1. LONGITUDINAL SECTION THROUGH PENSTOCK SHOWING LOCATION OF PIEZOMETER SECTIONS

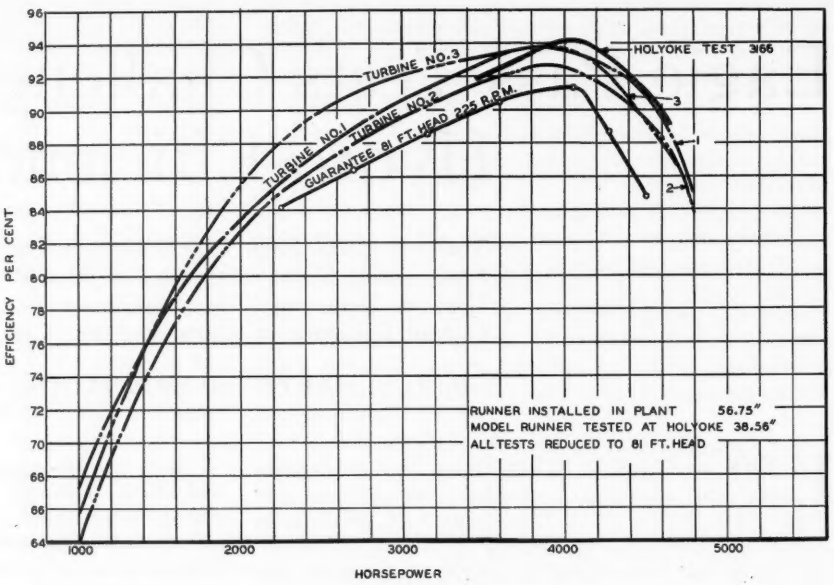


FIG. 2
EAGLE PASS
EFFICIENCY CURVES.

able, except that efficiencies are very sensitive to slight influences, especially in the case of units having small total losses as in this case. The particular setting of the runner as it affects disc friction on the upper crown, bearing friction, etc., and any differences in the roughness of the runner passages and any differences in the running clearances have an important effect upon the turbine efficiency. Furthermore, it is reasonable to expect a greater difference between individual unit efficiencies in the case of small units than in the case of units of larger size on account of the relative influence of variations in some of the losses. There may be slight differences in the disturbance in the water approaching the units. There are known to be small differences in the three runners due to unequal shrinkage of the castings. The differences in efficiency of these three turbines is not out of line with differences obtained in other tests where units were supposed to be identical. In general, the losses in a hydraulic turbine are not susceptible to the same degree of predetermination in design and of realization in the field as are the electrical losses of the generator.

Tests of Models

In Fig. 2 is shown a comparative diagram of the guaranteed efficiency of the hydraulic turbine, and of the Holyoke test No. 3166 upon which the design of the larger units were predicated; also the three turbine efficiency curves determined in the field by Gibson Test.

The high efficiencies both of the turbines and of the station as a whole are not to be accounted for by any one fact, nor to be credited to any one individual or organization. They are to be accounted for largely by close attention to detail in the design of all parts of the equipment and of the station itself.

The efficiencies of the turbine are more remarkable because of the fact that the manufacturer had no developed type of the specific speed specified and, therefore Holyoke tests of successive model runners were specified until a runner should have been obtained whose characteristics satisfied the consulting engineers. The second model runner which was built and tested at Holyoke was satisfactory, closely paralleling the guaranteed curve, as shown in Fig. 2, and gave a test at Holyoke of 94.57 per cent—the highest test ever having been made at Holyoke.

A small model of the successful Holyoke runner was also tested in the manufacturer's testing flume to verify the efficiency of the elbow draft tube as compared with a straight conical tube model of the one used at Holyoke.

In connection with the station as a whole, eternal vigilance was applied to eliminate losses wherever practicable without exorbitant expense. In this connection, it is significant that frequently the elimination of losses is not a matter of increased expense of manufacture or construction, but merely a matter of more care and attention to detail in the design accompanied necessarily by some increased engineering expense.

The curves of the intake structure were so shaped as to accelerate the water from the Forebay into the penstock as nearly as possible without disturbance and in the interest of uniform distribution of velocity over the section of both intake structure and penstock.

Small Penstock Losses

Probably the most important feature of the design contributing to small penstock losses and also contributing perhaps an important amount to high turbine efficiency was the use of a reducing elbow ahead of the turbine. It has been the practice of the designing engineers of this project for some years to make all contractions in sections where practicable at the elbows in the belief that the disturbances are very largely eliminated if the cross-section of flow contracts simultaneously, thus forcing the water to follow properly the elbow, even on the inside of the bend. The engineers have not previously, however, had an opportunity to verify the value of this refinement. That it is of value was demonstrated in the test of this station. The four piezometers located about the circumference of the penstock just ahead of the turbine scroll case for determining the net head on the turbine for efficiency calculations were located just below the elbow. Piezometers in such location would show considerable agitation if the elbow

were of constant section and probably all four piezometers would not indicate identical pressure. In this case, however, there was an active absence of disturbance in the piezometers at all loads and identical readings were obtained from the individual piezometers in all four quadrants of the penstock cross-section.

The design of the penstocks resulted in a low friction loss between the intake and the turbine. This loss was calculated from the test data. This was done without correcting for the velocity of approach at the intake and, though this is a small quantity, the total loss of head is also a small quantity so that the results may indicate a slight difference between the various units as to loss of head. This difference, however, is of the order of 0.2 per cent referred to the efficiency of the unit.

Values of loss of head were plotted on logarithmic cross-section paper against discharge, resulting in a curve with a slope of 2, showing that the loss increased approximately as the square of the discharge. The loss at around 450 c.f.s. for the three units varied between 0.13 and 0.25 ft.

Penstocks

Considerable data have accumulated in the last few years to indicate that a disturbance from any source ahead of a turbine will considerably affect the efficiency by carrying on through the runner. To avoid such disturbances, it is now good practice to use as long a horizontal tangent in the penstock ahead of the scroll case as possible to iron out the disturbances inevitably caused by a uniform section elbow in an S-shaped penstock installation, as in this case. Some recent stations have even gone so far as to use an intake in very deep water at the same elevation as the turbine in order to bring the water in from the reservoir to the turbine in a horizontal penstock without bends. This practice greatly increases the cost of the intake gates, trash racks, etc. Such design was, of course, impossible in this case because the canal at the top of the hill did not provide depth for a low level intake. It is believed that the high efficiency obtained in this installation, the lack of disturbance and the identical indication of the four peizometers just below the lower elbow, indicate that an S-shaped penstock can be used without detriment to the turbine efficiency if the lower elbow ahead of the turbine contracts in section.

Other features undoubtedly contributing to efficient results were such as conservative penstock velocities, conservative specific speed of the turbine and close attention to minor details. The efficiencies indicated are for 100 per cent power factor of the generators, which was controlled at this value for purpose of test.

The generator design is noteworthy in respect to the ventilation system, which receives the air at the center and on top of the generator from underneath the circular walkway. After passing through the coils, the cooling air is collected in an eccentrically positioned horseshoe-shaped steel drum around the generator proper, which discharges laterally through louvers in the power house wall directly to the atmosphere. Another noteworthy feature was the effort to utilize the advantages of the welded generator frame without unnecessarily sacrificing the appearance of the machine. The appearance of many welded machines built thus far in this country is not such as to encourage their use and has not always been a credit to the manufacturers, nor in keeping in appearance with the remainder of the station and equipment. The efficiencies of the generators at 100 per cent power factor were:

4000 kw.—97.2 per cent
3000 kw.—96.9 per cent
2000 kw.—96.1 per cent
1000 kw.—93.2 per cent

In no small measure the efficiency of this station can also be credited to the close cooperation beween manufacturers and consulting engineers during the development, design and manufacture of the equipment. Such cooperation can only result in benefit to the project as a whole and, therefore, to the client. The engineer, as a coordinating center between the several manufacturers, designers and the general contractor, is in a position to bring about a harmonious co-relation of details of all parts of the station and consequent improved performance. The equipment manufacturers are to be congratulated for their excellent results, especially the turbine manufacturers, whose equipment largely determines the efficiency of the unit.

As stated in the previous article in the August 1 issue, this hydroelectric project is the property of the Central Power and Light Co. of San Antonio, a subsidiary of the Central & Southwest Utilities Co. of Dallas, which in turn is a subsidiary of the Middle West Utilities Co. of Chicago. Mr. J. T. Persons exercised general supervision for the Central Power and Light, Mr. G. A. Mills for the Central & Southwest and Mr. G. W. Hamilton for the Middle West Utilities. With the exception of the substation which was engineered by the Central Power and Light Co., the Harza Engineering Co. of Chicago engineered the project, Mr. Erik Floor and Mr. Jas. S. Bowman in immediate charge of design; Mr. C. E. Wattles, resident engineer on construction. Bart Moore of San Antonio was general construction contractor; turbines by James Leffel; generator and switchboard by Westinghouse; governors by Woodward.

Swiss hydroelectric plants have found it necessary to provide settling systems to remove sand from the water before entering the water wheels. At high heads, the erosive action may result in necessity for replacing runners in 5 to 6 yr., whereas, if the settling area for sand removal is provided the wear may be reduced to 1/5 that without settling. The entrance channel is enlarged to reduce water velocity, screens used to steady the flow and water then passed into a deep chamber with V bottom. Sand in settling is guided toward an ejector which cleans the settling chambers. At Cardarno in northern Italy, desanding in a 270,000-hp. plant, the volume removed was some 20 per cent of the water volume. For low-head turbines, the effect is less serious and desanding equipment may be arranged at the entrance to the turbine chamber.

Exhibits at the National Power Show in Grand Central Palace, New York, Dec. 5 to 10 will be shown, where feasible, in operation. Actual tests, microscope enlargements and models in operation will illustrate the results of development and research in thermal and physical phenomena. Atmospheric pollution by smoke, gases and dust, with methods for elimination will be shown by city and federal departments as well as records of progress in pollution abatement.

POWER PLANT ENGINEERING December 1932

Boiler Feedwater Piping Design Features and Precautions

Consideration Is Given Here to Feed Pump Discharges, Feedwater Headers and Boiler Intake Piping Leads. By Henry C. Moffett*

IN THE DESIGN of a power plant piping system, boiler feed piping is rarely, if ever, considered alone, but along with the steam piping design. The two systems, taken together, comprise the primary circulating cycle of water and steam and, except for the make-up water, on the one hand, and the steam and water leakages on the other, and the boiler blowoffs, the cycle is closed; the water flowing into the boilers and the steam flowing out of the boilers to the generating units and on to the condensers where it is reduced to water again, ready to be pumped once more into the boilers.

Therefore, boiler feed piping design is subject to the same calculations, with slight corrections, as the main steam piping, which was considered in the October issue, and the same heat balance studies are used as a basis for the quantities flowing and for the determination of the proper pipe sizes.

As for steam piping, boiler feed piping should be carefully laid out in diagram, before an attempt is made to design it in detail. Such diagrams tend to clarify the whole picture and are useful in conferences where there may be differences of opinion as to methods of operation. It is much more economical to change diagrams than to alter detail drawings, even though they may be preliminary.

Feedwater Piping System

Boiler feed piping is usually spoken of as that part of the system between the boiler feed pumps and the boilers and is designed to carry hot water at a higher pressure than the steam in the main steam pipes. There are three distinct parts to such piping: (a) the boiler feed pump discharges, (b) the boiler feed header or headers, and (c) boiler intake piping leads.

In most modern plants today, the main boiler feed pumps are of the centrifugal type and are motor driven, while as stand-bys, there are one or more pumps of the same type, driven usually by a small steam turbine. All of these pumps must be piped into the boiler feed header. The discharges from the pumps invariably have check valves and gate valves as near to the pumps as possible. Some engineers prefer to regulate the discharge pressure into the boiler feed header by some kind of regulating valves in the pump discharge lines, and this was done extensively in the past. Most modern boiler feed pumps now have characteristics which when plotted as a curve show the operating pressures to be practically constant over a wide range of capacities, and when the pumps are properly chosen, it is possible to allow the full operating pressures to reach the boiler feed header.

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Boiler feed headers are designed in many ways. Some are complete loops, others are single lines blanked off at one end for extensions. Still others are double, or two separate headers. In such cases, it is necessary to have split pump discharge lines, as well as twin boiler intake leads. This requires many more valves and is only justified by the fact that shut-downs, due to trouble in the feed lines can be easily by-passed. For economical reasons, it is usual to split such lines beyond all check valves and regulators.

Feed Water Heating

Many of the modern plants heat feedwater, in part at least, by the use of closed feedwater heaters, the steam for which is bled from the turbines. Some plants have several such heaters and those that are fed by steam from the higher range of turbine stages are built to withstand the full boiler feed pressure in the tubes, as it is necessary to force all feedwater through them. This is usually accomplished by piping a by-pass from the boiler feed header to each heater and inserting valves in the line, so that such heaters may be cut out when necessary.

In very high pressure plants, two sets of boiler feed pumps are required, so that the full pressure necessary in the boiler feed header may be obtained in two stages. In such cases several auxiliary headers are necessary. The first pumps are known as booster pumps and frequently raise the pressure about half-way to the final pressure.

Economizer Piping

Leads from boiler feed headers to boiler inlets are provided with automatic feed regulating devices and where economizers are installed, these are inserted ahead of the economizer inlets. Beyond the economizer, and as close to the boiler feed inlet as possible, a special check valve, usually called a stop-check, and a hand operated globe valve are inserted.

For many years, when pressures were never above 250 lb. per sq. in., the water entering the boiler was controlled either by a single regulator, which was opened and closed by the water level in the boiler drum, or by a hand operated valve. Many such regulators are in use today. Some large plants do not have automatic regulators but depend on water tenders to operate hand valves.

As pressures increased, however, it became necessary to regulate the flow to the boilers more closely and for this purpose the differential pressure regulator was introduced. This regulator is almost always operated by a diaphragm, through a pilot valve, the operating pres-

sure of which is obtained from the feed piping itself, ahead of the regulator, while the regulation of the pilot is secured from the steam pressure inside the boiler drum. Both boiler feed regulators and differential pressure regulators are so constructed that they cannot be entirely shut off.

Good design dictates that boilers should be fed by two leads from the main header. If there are two inlets on the intake drum, one lead is connected to each inlet. One of these leads is equipped with all of the necessary regulatory devices; the auxiliary lead contains only hand valves. If the drum has only one feed inlet, it is necessary to lead both lines into this one point, using an appropriate fitting.

Ample Size Important

Boiler feed piping should be made amply large. The velocity of the flowing water should never exceed 10 ft. per sec. Many good designs have fallen short of perfection because the pipe sizes were too small. This is especially true in plants that have a widely varying steam demand, as it is absolutely necessary to get water into the boilers at peak loads, when the steam is drawn out rapidly. It is therefore unwise to skimp on such piping, as it may reduce the capacity of the plant. Valves, regulators and fittings all cause frictional resistance which is much larger than the friction in the pipe line itself and, as the speed increases, the frictional resistance increases almost as the square of the speed.

For instance, take the following comparison of a 4-in. with a 3-in. pipe, calculated with factors based on 17 yr. in service.

Gal. Per Min.	Velocity in Ft. Per Min.		Head Loss in Ft. Per 100 Ft. of Pipe	
	4 in.	3 in.	4 in.	3 in.
100	2.55	4.54	1.22	4.96
200	5.11	9.08	4.40	17.80
300	7.66	13.62	9.30	38.00
400	10.21	18.16	16.00	65.00
500	12.77	22.70	24.00	98.00
600	15.32	27.23	33.70	137.00

It is evident from the above, that a 4-in. pipe has twice the capacity of a 3-in. pipe, at approximately the same speed of flow, and about one-quarter the frictional resistance per hundred feet of pipe, at the same rate of flow.

Fittings used in boiler feed lines are usually identical with those used in the main steam lines, except that sweep tees and long radius elbows are specified, to reduce friction. The American Standard B 16e-1927, "Steel Pipe Flanges and Flanged Fittings," allows the following non-shock hydraulic ratings at 450 deg. F., such as boiler feed lines, for fittings based on maximum steam working pressures given:

325 lb. per sq. in. water, 250 lb. per sq. in. steam; 500 lb. water, 400 lb. steam; 720 lb. water, 600 lb. steam; 1080 lb. water, 900 lb. steam; 1625 lb. water, 1350 lb. steam; this water pressure is sufficiently higher than the corresponding steam pressure to allow the same flanges and fittings, of like standard, to be used for both steam and boiler feed lines in a given plant.

Unless all air is removed from the condensate, boiler feed piping is subject to the corrosive effect of oxygen in hot water, which has a tendency to form rust and pit the inside of the steel tubes. Inasmuch as it is practically impossible to remove all of the dissolved oxygen in the boiler feedwater, engineers usually specify slightly thicker pipes for boiler feed lines than would otherwise be necessary to withstand the pressures. In some recent 400-lb. steam plants, the entire boiler feed piping was specified for 600-lb. standard practice.

The American Society for Testing Materials publish a Standard Specifications for Lap-welded and Seamless Steel Pipe for High Pressure Service, known as ASTM Designation A 106-29 covering the range of pressures from 250 lb. per sq. in. to 1350 lb. per sq. in. inclusive. These specifications give the recommended pipe thicknesses for the various working pressures for both water and steam, as well as the physical and chemical requirements of the steel to be used and its manner of manufacture.

General Precautions

As far as possible, the design of boiler feed lines should be such that the water will flow around smooth bends, whenever a change of direction in the piping is necessary. The use of bends will also add to the flexibility of the lines, and prevent damage that might result from vibration or water hammer. Systems that are too rigidly constructed are liable to leak at the joints, due to strains set up by expansion, or the loosening of bolted joints from vibration.

All pump discharges should be as nearly identical as is possible to design them, for the sake of appearances. Regulators and valves should be conveniently located, so as to simplify the operator's task. Horizontal lines should always be high enough to clear a man's head, where they are in or cross a main passageway.

Anchorages should be used with caution and only such anchors installed as will not throw unnecessary thrusts on equipment. Headers may be anchored at some mid-point, but leads should never be anchored close to connected machinery.

Water hammer is often the result of poorly designed systems. In some cases, water relief valves have been installed near pumps to relieve surges of pressure, caused by sudden closing of valves.

Boiler feed piping should be so installed that all lines will drain by gravity when it becomes necessary to empty them. In other words, pockets in which water can stand, such as inverted loops and the like should never be allowed, unless some means is provided to drain them when a line is closed down for inspection or repairs.

There are some differences of opinion as to whether or not boiler feed lines should be covered with insulation. Many systems are left bare, as it is argued that the cost of covering is not justified by the savings.

Engineers, when locating equipment in a power plant, as for instance, the boiler feed pumps and the heaters through which feed water must be pumped, should give due consideration to the piping before deciding finally on such locations.

Active aid of engineers in expediting loans on self-liquidating construction projects is urged by William S. Lee, president of American Engineering Council, as an aid to the work of the Reconstruction Finance Corp. Engineers have been placed on the advisory councils of local agencies to help inform the public as to the character of projects that can be financed. Engineers, by helping to expedite the work can aid in relieving unemployment and applicants are urged to employ their own engineers on every project.

POWER PLANT ENGINEERING December 1932

Silencing Exhaust Noises of Diesel Engines

HUMAN EAR CANNOT BE DEPENDED UPON. INSTRUMENTS NEEDED. BACK PRESSURE AND SUCTION RESISTANCE MUST BE LOW IN A SUCCESSFUL INSTALLATION. RESULTS OF TESTS. BY JOHN M. DRABELLE*

ONE OF THE LITTLE appreciated problems, particularly to the uninitiated, in connection with diesel engine power stations is the problem of silencing the exhaust of the engines. To silence an engine without regard to the back pressure developed on the engine exhaust or suction loss on air intake is one thing, but to silence an engine without producing undue back pressure on the exhaust with consequent decrease in output is quite a different story.

Recently an investigation was carried out by the writer at a power station, where those living adjacent to it complained of the noise of the station and brought a case to trial in the District Court praying for a writ of injunction and asking that the station be declared

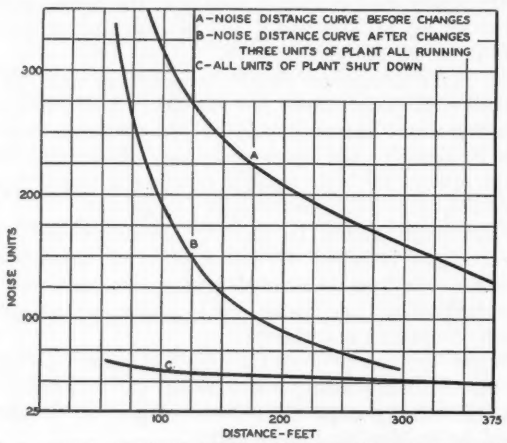


FIG. 1. TEST CURVES SHOWING EFFECTIVE SILENCING

a public nuisance and enjoined from operating. As considerable money had been invested in this station and all of the ordinary and customary things had been done to silence the exhaust the problem was not a simple one. Early in the study it developed that the human ear and human opinion, as to whether some curative measures had or had not produced a betterment, were found to be an impossible standard to judge from.

NOISE MEASUREMENT

A noise volume measuring instrument was secured from the telephone company and the study carried out by actually measuring the volumes of sound produced under various conditions of silencer arrangement. For various arrangements tried, see Fig. 2. The device used was a Western Electric No. 10-A noise set, which consisted of an electric vibrator system delivering a scrambled noise to the receiving system. An open back telephone receiver was used with a circuit equivalent to an Ayrton shunt box, by which the amount of output from the sound generator could be varied into the telephone receiver, and when the energy delivered to the receiver was sufficient in quantity to be just heard above the noise coming through the open back of the receiver, this reading was called the noise value. This instrument was not graduated in the newer unit, the Decibel, and the curves shown are plotted in this arbitrary unit and not the Decibel.

Stations were set up on a map so that all readings could be compared to definite locations. Readings were taken at the four points of the compass at various distances from the power station, and by changes in the exhaust piping, silencing equipment and exhaust stack arrangement, various levels of sound were determined.

These results were plotted and the amount of noise observed in any particular station as compared to any other particular station seems to obey the same fundamental laws as light, namely, the law of the Inverse Square, which briefly stated is, that if you double the distance from the source, you decrease the noise to one-fourth of the value at the previous station.

Engines involved in the study were two-cycle pump scavenging, solid injection diesel engines, operating at a speed of 257 r.p.m. and having a nominal rating of 720 hp. The higher speed, two-cycle engine presents a more serious problem in silencing than the slower speed four-cycle, either solid or air injection units, due to the higher frequency of exhaust of the two-cycle unit.

SOME DEVICES USED

Manufacturers of diesel engines do not appreciate the real seriousness of this noise situation and apparently have little, if any, data in their engineering departments as to the solution of noise problems. It has apparently been left largely to trouble men, who during years of experience, have learned of various stunts. Unfortunately, most of these stunts when tried, produced serious back pressure conditions upon the engine, which leads to higher exhaust temperatures and decreases output.

The under-ground pit is a favorite solution of the trouble man, but the pit usually constructed of concrete is subjected to rather high temperatures with the consequent cracking. It also becomes a catch-all for unburned carbon, lubricating and fuel oil so that ultimately it forms a fire as well as an explosion hazard and the impact of the exhaust in the pit produces definite earth vibrations that can be felt for quite a distance in the surrounding territory.

One silencer tested consisted of a steel cylinder with a series of discs with openings arranged concentrical.

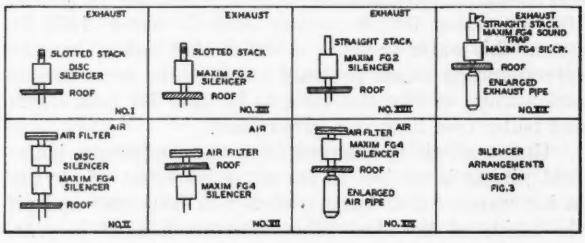


FIG. 2. SOME OF THE SILENCER ARRANGEMENTS USED

*Mechanical & Electrical Engineer, Iowa Electric Light & Power Co., Cedar Rapids, Ia.

AIR SUCTION					
TEST RUN NO.	114	103	112	115	
UNIT USED - PLANT NO.	1	1	1	2	
SIZE OF AIR PIPE - DIA.	16"	16"	16"	16"x36"	
LENGTH OF AIR PIPE.		20' 8"		13' 0½"	
MAKE OF SILENCER.	MAXIM	MAXIM	MAXIM	MAXIM	
TYPE NO. OF SILENCER.	FG4	FG4	FG4	FG4	
SERIAL NO. OF SILENCER.	372813 &28	372813 &28	372813 &28	372813 &28	
ARRANGEMENT NO.	XII	II	XII	XIV	
DISC USED	NO	YES	NO	NO	
LOAD IN KW					
0	7.35	13.70	7.35	4.6	
100	7.38	13.65	7.35	4.6	
200 VAC.	7.40	13.60	7.35	4.6	
300 INS. H_2O	7.40	13.20	7.45	4.5	
400	7.40	13.30	7.45	4.5	
500	7.40	13.25	7.45	4.5	
EXHAUST					
TEST RUN NO.	114	103	112	115	
UNIT USED - PLANT NO.	1	1	1	2	
SIZE OF EXHAUST PIPE - DIA.	16"	16"	16"	16"x36"	
LENGTH OF EXHAUST PIPE.	20' 8"	20' 8"	20' 8"	14' 7"	
MAKE OF SILENCER.	MAXIM	DISC	MAXIM	MAXIM	
TYPE NO. OF SILENCER.	FG2	NONE	FG2	FG4	
SERIAL NO. OF SILENCER.	3421	NONE	3421		
ARRANGEMENT NO.	XVIII	I	XVII	XIX	
STACK USED.	STRAIGHT	SLOTTED	SLOTTED	STRAIGHT	
LOAD IN KW					
0	4.90	9.75	4.15	5.0	
100	5.05	10.25	4.35	5.3	
200 PRESS.	5.08	10.65	4.40	5.8	
300 INS. H_2O	5.32	11.20	4.70	6.0	
400	5.50	11.75	4.95	6.3	
500	5.75	12.50	5.10	6.3	
AVERAGE GROSS NOISE AT 150'	97	150	103	98	
AVERAGE NOISE PLANT SHUT DOWN	55	55	55	55	
NOISE INCREASE DUE TO PLANT.	42	95	108	43	

FIG. 3. TEST RESULTS SHOWING BACK PRESSURE NOISE READINGS AND VACUUM IN AIR SUCTION LINE

This device, however, while producing a slight diminution of sound level, produced serious back pressure conditions upon the equipment, as shown in Test 103, Fig. 3. Curves of noises are shown in Fig. 1. The lower curve shows the extremely important point played in studies of this character by the normal noise level of the town which must not be overlooked. There is no such thing as absolute quiet. As the work progressed in this noise study, it became apparent that we had reached a limit below which it was impossible for us to go with the means at hand.

Analysis of Noise

As the noise measuring instrument only would not analyze these complex sounds into their respective components a frequency analyzer was made use of. This consisted essentially of a radio broadcasting microphone which was located on the roof of the power station. From this a circuit was run back into the building where a frequency analyzer was located. When the various component parts of the complex sound wave were analyzed, it was found that a low frequency 40-cycle note together with a 60-cycle note and a second harmonic were the principal disturbing factors.

Low frequency notes from the engine exhaust have the peculiar property of carrying a considerable amount of mechanical energy for a considerable distance and it is these low frequency components that produce the rattling of windows and the sensation of impact and pressure upon the human ear.

The research department of a silencer company was employed to suggest remedies, and after a frequency analysis was made by their engineers, an additional sound trap was installed upon the exhaust silencing system. The results obtained are shown on the curves on Fig. 1, curve A being the noise readings with all three units in operation before any changes were made, Curve B is the noise-distance curve after changes were made and sound traps installed in accordance with the recommendations of the engineers and Curve C is the normal noise level of the town in the vicinity of the station with all units shut down. An examination of these curves shows what was accomplished by placing the air silencers next to the intake flange on the scavenging air compressor cylinder and adding the sound trap.

Summing up this investigation the following facts stand out: First, that diesel engine manufacturers are not acquainted nor conversant with (and apparently are not much interested in) the problem of noise reduction; second, that the fundamental laws covering the amount of sound picked up at any given location from the power station, obeys the law of the inverse square; third, that the low frequency notes produce the rattling of windows, the sensations of pressure, and can only be eliminated by the addition of sound traps, especially designed by those thoroughly conversant with problems of sound and sound mitigation; fourth, that betterment of conditions can be secured by increasing the diameter of the exhaust pipe, making it approximately fifty per cent larger than that of the exhaust outlet of the engine and the inlet to the silencer system; fifth, that silencers installed on scavenging air pumps or air intakes will produce better results when installed close to the intake of the air system of the engine rather than upon the roof or immediately outside of the station; sixth, that no hard or fast rules can be laid down, as changes in diameter and length of exhaust, and air piping, together with the various different speeds of the units, differing with each engine manufacturer, introduce a series of exceedingly complicated variables which makes each installation a separate study.

Minor Changes That Improved Economy

As CONSULTING engineer for a club where, during quite a long period each spring and fall, the boiler pressure drops to zero due to no heating being required during several hours of the day but still a fire is maintained, I was able to make use of this heat by installing a submerged heater to supply hot water for the premises and supplementing it with a gas fired automatic low-pressure boiler which supplied steam to a coil in the same tank which is connected to the submerged heater.

This has enabled the fireman, who has many other duties besides firing the boilers, to spend less time worrying about the hot water and the total cost of operation on the premises was reduced through this and a number of other changes.

In another small plant where one man is fireman, engineer and maintenance man, I am contemplating installing a CO_2 recorder with a signal at some low limit so that when holes develop in the fire bed and the CO_2 drops the man looking after the boiler will immediately be appraised of it and take care of it rather than get on the job 10 or 15 min. later and thereby save uneconomical operation.

In the last 2 yr. the writer has found that the small plants which formerly were neglected by both the owners and professional engineers are receiving attention and have many probabilities where reductions in operating cost may be made.

Newark, N. J. J. G. BERGER.

Readers' Conference

Fuel Savings vs. Fixed Charges

WHETHER an improvement being contemplated, will be profitable in dollars and cents, must necessarily be considered before making any change in operating equipment. To be profitable, the saving in fuel, labor and maintenance must be greater than the fixed charges on the investment to be made. Balancing the fuel saving only against the fixed charges, the maximum additional justifiable investment per kilowatt of installed capacity is a function of the fuel cost, fuel saving, plant capacity factor and fixed charge rate. Plant capacity factor is the ratio, expressed as a percentage of the yearly kilo-

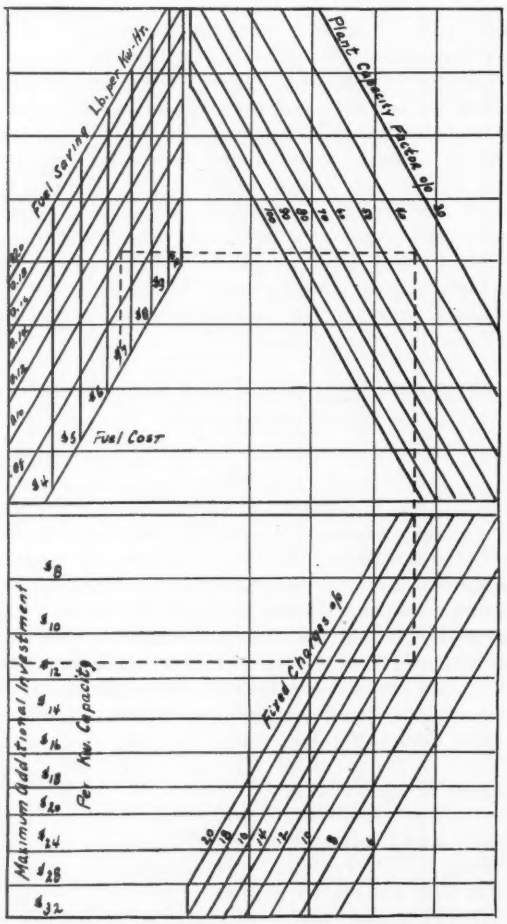


CHART FOR DETERMINING ADVISABILITY OF ADDITIONAL INVESTMENT.

watt hours generated to the kilowatt capacity installed times 8760 which represents continuous service at rated capacity. The accompanying chart, showing the relation of these quantities, indicates that a higher investment may be made for higher fuel cost, larger fuel savings, higher plant factor and lower fixed charges.

The chart is based on a formula developed by equating the coal savings effected to the fixed charges on the improvement.

$$I = (4.38 \times S \times C \times P)\, F$$

Where I = max. justifiable investment; S = coal saving lb. per kw-hr.; C = coal cost, dollars per t.; P = plant capacity factor per cent; F = fixed charges, per cent.

Coal cost, plant capacity factor and fuel saving are more or less fixed by the existing plant and contemplated improvement but some thought must be given to the value of the fixed charges which includes interest, amortization, taxes and insurance. The latter two items may, in most cases, be neglected since they will be very small for any plant improvement. Interest rates vary from 4 to 8 per cent but may be taken at 6 per cent for ordinary cases. The amortization or paying off of the investment depends on the assumed life of the equipment which may vary from 5 to 25 years with corresponding yearly amortization of 15 to 4 per cent. Thus, before assuming a fixed charge rate, life expectancy and interest rates must be investigated.

Westfield, N. J. GORDON R. HAHN.

Fouling of Rectifier Cooling Jackets

WATER JACKETS of mercury arc rectifiers and their pumps are likely to foul and corrode if the water contains impurities. The total hardness of the water used should not exceed 17 grains per gallon. The chloride, sulphate and nitrate content of any alkali must not exceed 0.8 parts by weight per 100,000 parts of water. The chloride content of the above must not exceed 0.6 parts by weight per 100,000 parts of water. The specific resistance of the water must be at least 2000 ohms per centimeter cube.

Best results seem to be obtained where a completely closed recooling system is used. This increases the first cost of the unit and additional power is needed to drive the additional necessary plant. By this means, however, heavy maintenance costs due to the corrosion and scaling of the cylinder walls are avoided. Scaling of the walls seriously affects the operation of rectifiers and at the first signs of scaling the jackets should be cleaned, the joints remade and tested with air at 60 lb. pressure.

Herts, England. W. E. WARNER.

Belt Idlers Cannot Drive

I READ with exceptional interest the article by R. F. Emerson, page 780, in the November number of Power Plant Engineering, entitled, "Driving Conveyor Belt Idlers by Motors." The thing that first struck me was the apparent inconsistency in meaning of the heading. I wondered whether it really meant what was implied, and I found that Mr. Emerson did mean it.

This is not a criticism of Mr. Emerson. The error is so common that it is excusable. What I am trying to do is to suggest a proper name for such a pulley as described by Mr. Emerson.

Surely an idler pulley can be nothing more nor less than what the name signifies—an "idler." Idler pulleys have been used for so many years that there can be no question regarding the true meaning of the term "idler" —a pulley that doesn't do any real work—that doesn't push, pull, tighten, or wrap.

Just as soon as a motor is attached to any pulley, and that pulley assists the main drive motor which drives the head pulley, one certainly can no longer call it an idler pulley. It becomes a "driving pulley," pure and simple, even though it is nothing more nor less than an assistant to the main driver. Why not call it an "auxiliary driving pulley?" Or, "an idler pulley converted into an auxiliary driving pulley?"

Newark, N. J. W. F. SCHAPHORST.

Generator Characteristics Changed by Fire

A MOTOR GENERATOR set of 150 kw. capacity direct current was burned when the building in which it was installed caught fire. The machine winding was destroyed as was also the commutator. The brush-holders were ruined. However the machine was rebuilt and when installed gave perfect satisfaction and believe it or not it was only necessary to excite the fields one time and the voltage would build up.

There was one fault in operation, however, and that was that the machine would drop voltage instead of rising as the load came on. Everything was checked closely, brushes were shifted, etc., and everything in reason was done to make the machine raise voltage.

As a last resort the shunt was reduced and finally cut out altogether. The voltage would not rise with load until the shunt was cut entirely out. As all the fields were identical and connected as originally, with same number of turns and leads brought out the same point, it is evident that the fire must have affected the iron to a certain extent. The change although not large was enough to cause the machine to drop voltage when heavy loads were thrown on suddenly.

Birmingham, Ala. G. H. EMERSON.

Roller Bearing Lubrication

MR. SCHAPHORST'S article in the August 15 issue concerning the lubricant regulation on roller bearings, recalls an experience I had with the roller bearings on a high speed pump handling water at the boiling point.

Periodically these bearings would give trouble by running hot. After a thorough clearing they would run at normal temperatures for a while and then the same cycle of dismantling, cleaning and replacing was gone through. Alinements were checked and found to be proper. Whenever the bearings were uncovered they always contained a muddy-looking deposit, of a consistency heavier than the grease used, several grades of which were tried, but none was found that wholly eliminated the trouble. The bearing housing was of a closed type, with no opportunity for outside dirt to work in, so it was evident the deposit was being carried with the grease.

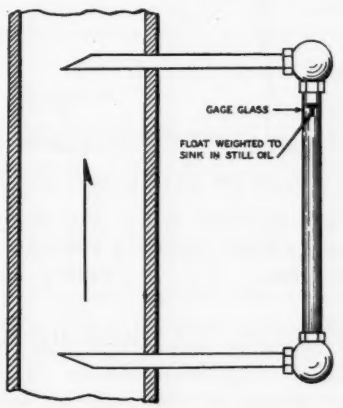
The problem was referred to an engineer with knowledge of the manufacture of greases, who claimed that some greases carry fillers and our deposits were accumulations of that filler. To overcome our difficulty a change was made to another grade not containing a filler. No trouble was experienced afterward.

Referring lubricating problems to specialists in that line produces the best results.

Matawan, N. J. GEO. B. LONGSTREET.

An Inexpensive Oil Flow Indicator

IN A PLANT with four cross compound blowing engines we had a central oiling system with a pump in the basement pumping from the filter to the overhead tank. In order to check up on the operation of the pump it was necessary to go down to the basement occasionally which



at times of heavy load was inconvenient. One of these pumps ran at all times full speed and the overflow ran back to the suction. In this way we avoided any possibility of a failure of a float switch to operate. So that the engineer on watch could see from the engine level whether the pump was operating, we fixed up the flow indicator as shown in the sketch. The float was made of a piece of light wood and weighted on the bottom with a small nail so that it would just sink in oil. A small flow through the pipe would be enough to overbalance its tendency to sink and as long as the pump was operating the float would be at the top of the glass. Against a white background this could be seen across the width of the engine room.

Springfield, O. F. PAUL.

Return Trap Failure

RETURNS FROM the heating and process work, as shown in the diagram, drained into Trap No. 1 in the basement which lifted the water of condensation 24 ft. to a receiving tank. From this tank the water was supposed to go into tilting trap No. 2 and be forced into boiler. The receiving tank had only about ½ the capacity of trap No. 2. A meter was installed in the discharge line of the trap but it didn't meter. Also trap No. 2 never dumped. Boiler pressure of 95 lb. gage was carried on everything. There was no trouble about all heating surface delivering heat properly; trap No. 1 worked regularly, but trap No. 2 and meter, stood still. I was asked to find out why.

Solution: The top line of the receiving tank was below the center line of No. 2 trap and water was flowing from the receiving tank through inlet and discharge pipes of the trap into the boiler without enough going

into No. 2 trap to dump it. I discovered also that below a certain rate of flow the meter would not register. As shown by dotted lines, I lowered No. 2 trap so that it was below receiving tank and carried the discharge line clear up to the ceiling. I moved the meter to the posi-

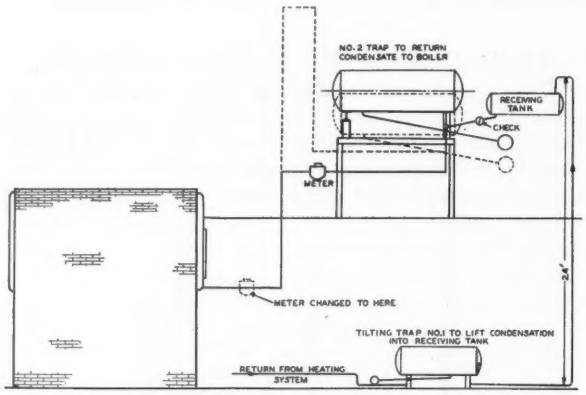


DIAGRAM OF TRAP CONNECTIONS

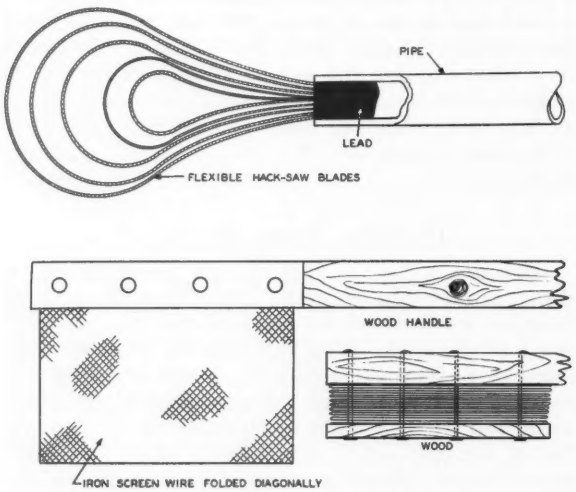
tion shown and after the change trap No. 2 worked as designed and the meter registered 1800 gal. in 12 hr.

Minneapolis, Minn. FRED S. RUTLEDGE.

Two Brushes for Cleaning Rusted Ironwork

ONE SHOP WHICH has much painting and enameling work on fences, rails and structural iron, made up scouring brushes for cleaning in the simple manner shown in the attached sketch. For heavy rust and scale, old saw blades, of the flexible back type, are bent and secured in a pipe handle with molten lead. The sharp saw edges are rapid cutters and the tool is flexible enough to reach into crevices.

A finer tool is made from screening, such as is used



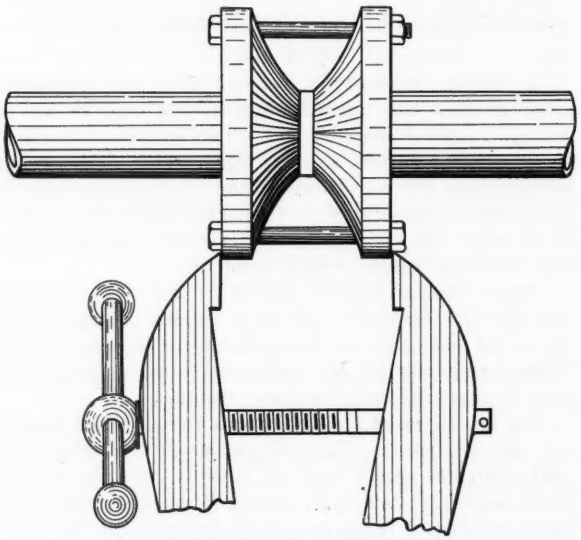
IMPROVISED BRUSHES FOR CLEANING IRONWORK

in fine sieves and for screening paint. The screen wire is folded diagonally and nailed to a wooden handle. This brush will also clean rust from uneven surfaces and is used on such surfaces as are in fair condition and also used after the saw brush first described. These tools are readily duplicated by any shop experiencing difficulty in obtaining suitable brushes for heavy rust and scale.

Washington, D. C. G. A. LUERS.

Flange Bolt Replaced

IN THE ACCOMPANYING sketch is shown a method whereby an engineer friend tightened a leaky joint in a liquid ammonia pipe line. He did it without first emptying the pipe to make the repair and without turning off the pressure. The lower bolt, shown in the sketch, was too short in the threads. That is, it was not threaded sufficiently so that the engineer's assistant could turn the nut on farther. Test with a sulphur candle showed the joint to be leaking on the lower side. The engineer did not know what was the matter with the bolt at the time but he learned afterwards—after removing it.



SCHEME FOR REPLACING A BOLT

To replace the bolt the engineer took a small vise off the bench and blocked it up under the pipe, as indicated, so that the jaws firmly caught the edges of the flanges. He then tightened the vise jaws and relieved the bolt of its stress. Then he took off the nut from the bolt, removed the bolt itself and replaced it with another which was sufficiently threaded, and tightened it. The leak disappeared. The plant continued to operate without any hold-up whatever. W. F. SCHAPHORST.

Newark, N. J.

Convenient Light for Boiler Cleaning

WM. H. DEELEY'S idea described on page 730 in the October issue prompts me to suggest what I consider a much more practical method of lighting a boiler interior while it is being washed.

The light wire is run through an ordinary ½-in. garden water hose, a fiber socket for the light bulb is used and the socket well wound with rubber insulating tape, with a wire cage guard over the light bulb. The socket is held firmly and water tight at the end of the hose by windings of the rubber tape. Even should the light bulb get broken and water come in contact with the broken end of the bulb, no greater harm will occur than burning out a fuse plug.

Toronto, Can. JAMES E. NOBLE.

Plant Operation Problems

Synchronizing with Power Company

OUR FIRM, a small manufacturing firm, has contracted with the local power company to exchange power so as to balance the heating requirements for the coming winter. The prime mover of the plant insists of a direct connected Erie Ball Engine and 540-kw. generator. Our heat requirements are approximately 500 kw.; the plant load for the coming winter probably will not exceed 200 kw. We figure on synchronizing with the power company so as to have a better heat balance.

As this operation is new to the writer, I would appreciate information in regard to the following questions:

1. Is it possible to synchronize without the use of a motor driven synchronizing device? This device will cost our company approximately $1000, and they do not feel at this time that they can afford to spend this amount of money.

2. If the machine could be synchronized with the power company without synchronizing device, is it possible to control the load that the machine would pull; that is, if the heating requirements during mild weather would be, say 300 kw., would we be able to have control of the load on the unit under those conditions?

Perhaps other readers can provide me with the benefit of their experience along this line. C. P.

Generators as Synchronous Condensers

WE UNDERSTAND that considerable improvement has been made in operating conditions in many places by operating generators as synchronous condensers. Are the turbines operated also? If not how are the generators started and paralleled?

D. B.

A. Sometimes the turbine is operated at the same time, leaving sufficient steam leakage past the throttle to cool the turbine by absorbing the windage losses. Sometimes the turbine is cross connected to another condenser to reduce windage loss and make steam leakage unnecessary. It is more common however to disconnect the turbine. The following method of operating the generators as synchronous condensers was given to the N.E.L.A. by the Puget Sound Power & Light Co.

Some unusual operating experiences have been had in the use of the generators as synchronous condensers. One unit is used to start the other generator after opening its coupling to the turbine. The starting procedure is as follows:

The spare exciter provides excitation to both generators. There is no rheostat in the field circuit of either generator so that it is impossible to have, in starting, a large field current in the driving unit and a small field current in the condenser.

An oil pump supplies oil at 900 lb. to the bearings of the condenser to cause the shaft to "break away" from its bearings and thus to start easily. With both units at rest, the necessary oil circuit breakers are closed, connecting the 2 armatures together. The field breakers to both generators are closed and a field current of approximately 50 per cent is applied to each.

The turbine is started slowly to prevent the driving generator from pulling away from the synchronous condenser and the 2 are brought up as a unit. When both are at speed, the synchronous condenser is phased-in on the line and its excitation transferred from the spare exciter to the shaft exciter on the end of the condenser. The starting turbo-generator is then disconnected and shut down.

Lubrication of Anti-Friction Bearings

IN REPLY to J. J.'s inquiry appearing in your August 1 issue in regard to the lubrication of medium-size motors with anti-friction bearings, I offer the following comments and recommendations.

In general, temperature and speed are the main factors to be considered in the selection of a correct motor lubricant. These factors are to a certain degree inter-related, since high speeds are accompanied by a temperature rise and, vice versa, low speeds are generally accompanied by a moderate or low temperature.

Method of Application	Temperature	Sp.Gr.	Lubricant Characteristics					
			Pour °F.	Fire °F.	Flash °F.	Viscosity 100 °F.	Viscosity 150 °F.	Viscosity 210 °F.
Bath or splash	Normal	.910	15	430	380	285	128	47
" " "	Over 150 F.	.920	15	460	400	500	200	55
" " "	Below 32 F.	.920	15	420	370	235	112	45
Grease cup	Normal	A high-grade, neutral, i.e., acidless, No.3 cup grease of lime soap base free of moisture.						
Grease packed or pressure gun	Normal	A No.2 grease of the above specifications.						
Grease cup	Over 150 F.	A No.3 soda soap grease of high quality.						
Grease packed or pressure gun	Below 32 F.	A No.2 grease of lime soap base and of high quality						

High temperature reduces oil viscosity or body, while low temperature increases its viscosity. Hence, an oil that is suitable for normal operating temperature may prove unsuitable at some higher or lower temperature. Surrounding temperatures below 32 deg. F. require an oil of low pour test, in order to insure ready distribution at starting. Low viscosity is not essential, as higher temperatures are reached during operation. Operating temperatures over 150 deg. F. require the use of an oil of heavier body than when normal operating temperature is encountered.

Likewise, similar considerations must be given the selection of greases. Low temperature requires a soft or medium consistency grease for distribution, while high temperature, over 150 deg. F., requires a special grease which will resist separation under continuous heat.

High-speed conditions require that the lubricant be sufficiently quick-acting to reduce fluid friction to a minimum. Low-speed conditions permit of the use of a heavier bodied lubricant.

Specifically, for medium size motors the lubricants given in the table will give satisfactory service if correctly applied in the proper quantities.

Too much oil or grease in anti-friction bearings is often a cause of their overheating and the creeping of the lubricant along the shaft onto the commutator or slip-rings and windings. Experience shows that such bearings operate best about one-third full. The depth of lubricant carried in these bearings is of great importance. It is advisable, if possible, to provide an overflow at the correct level, to prevent overfilling.

Blacksburg, Va. JAMES I. CLOWER.

What Happens When the Field Switch Opens

REFERRING to Mr. E. B. Heise's article in the August 1st issue, relative to what happens when the Field Switch Opens, Mr. Heise will no doubt agree with me that in order to operate alternators in parallel satisfactorily, their prime movers must have drooping speed load characteristics. By referring to any typical speed load curve he will see that for a given frequency, the alternator can deliver only a definite load. Any elementary text book on Electrical Engineering will reveal that the load on alternators in parallel cannot be changed appreciably by changing the field current.

In regard to the type of primemover, Mr. Heise mentions synchronous motors. It is very unlikely that this type of motors was used in the generating station mentioned. If the prime movers had flat speed load characteristics as Mr. Heise suggests, the operation of the alternators would be unstable, that is, very small disturbances or changes of frequency would cause very large fluctuations in the kilowatt load delivered by each machine. This condition would result in serious operating difficulties.

Assuming that the average alternator becomes an induction generator when it loses its field excitation, as Mr. Heise suggests, the induction generator must be operated in parallel with synchronous machines. The voltage of the generator will depend upon the magnetizing component of the primary current and unless the load calls for a component equal to this, the generator will lose its voltage. The function of synchronous apparatus operated in parallel with an induction generator is to absorb the magnetizing component of the primary current, or more correctly stated to adjust the power factor of the load on the induction generator to that at which it can deliver the required power.

With respect to the synchronous apparatus in parallel with the induction generator, the magnetizing current which leads when referred to the terminal voltage of the induction generator, becomes a lagging current when referred to the terminal voltages of the synchronous apparatus. The synchronous apparatus must not only supply whatever lagging current is called for by the load but must also supply a lagging current equal to the leading magnetizing current of the induction generator.

If an induction generator operates in parallel with a synchronous generator, the voltage of the induction generator is equal to the voltage impressed across its terminals by the synchronous generator to which it is connected. The magnetizing current automatically adjusts itself to gain this voltage. The frequency is determined by the frequency of the magnetizing current and is the same as the frequency of the synchronous generator. The load is fixed by the rotor current which depends on the slip.

If two or more alternators operate in parallel and the excitation is removed, Mr. Heise states that the unit without excitation will speed up. As soon as the speed increases, the frequency is increased and the machines will fall out of step. Hence, I still maintain that if the machines referred to in the original problem continued to operate, the load was not shifted by the field switch opening.

Ossining, N. Y. EDWARD W. JOHNSTON.

What Caused Reversed Flow?

I WAS VERY much interested in E. W.'s reversed flow problem because I ran into almost an identical situation a short time ago.

The way I figured it out was that the moment the water in the heater starts to warm up it naturally begins to expand and the flow will go through whichever pipe offers the lower resistance. The difference in resistance need be only very small and is probably due to scale or restricted union gaskets. If the "inlet" pipe has the lower resistance, then the warmed water will flow that way and, of course, establish a temperature difference in the two pipes. This, since they are both the same height, keeps the circulation going in the direction it was started.

To overcome this trouble, I disconnected the discharge pipe and reconnected it to a tee put in the house supply line. This worked wonders because when water was drawn from any of the hot water faucets the pressure in that line reduced and, while most of the water would flow direct from the tank, acceleration of water would also occur through the heater discharge line and thus the water was forced to flow in the proper direction.

I believe this is a better method than installing a check valve because I have found that heater pipes last longer and scale less, if the circulation through them is rapid. Anything like a check valve offers considerable resistance when you consider the small flow pressure due to the temperature differential.

Of course the best way to cure the trouble would be to run the heater inlet line direct and avoid the hairpin loop even if this involved cutting a hole for the pipe through a concrete wall. Even with the changed connections, the tendency will still be to flow in the wrong direction every time a fire is made and this will continue until someone opens a hot water faucet and thus establishes the correct direction of flow.

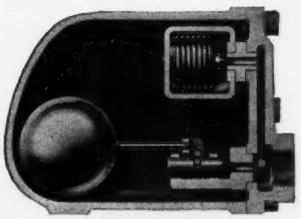
GEORGE P. PEARCE.

THREE-SECTION locomotive boilers are in use experimentally by the Canadian Pacific and New York Central railroads, one section carrying 250 lb., a second, 800 lb. and a third closed heat-transfer section 1400 lb. They are a joint development of American Locomotive Co. and the Superheater Co., having 2 to 3 per cent nickel steel plates in the 250-lb. section and 3½ per cent nickel steel forgings for the higher pressure sections.

New Equipment

Float Trap

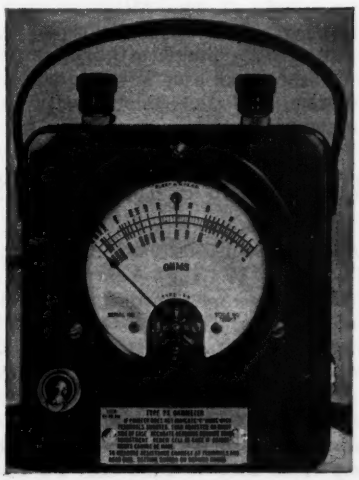
IN THE NEW FT-0 trap made by Sarco Co., Inc., of New York for use on risers, small mains and unit heaters, features are a thermostatic air bypass vent inside the trap, spherical-head outlet valve to give large capacity, all working parts attached to the cover, to which also inlet and outlet connections are



made near together for compact installation. By removing the trap body, without breaking piping connections, all parts are exposed for easy servicing.

A Double Reading Ohmmeter

NEW DOUBLE-range ohmmeter, announced by the Westinghouse Electric & Manufacturing Co. requires no external source of voltage for its operation, and measures ohms

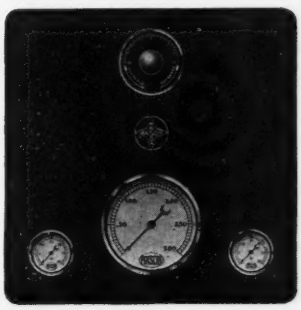


directly. The resistance ranges of 5000 and 50,000 ohms, are selected by flipping a toggle switch. Powered by an ordinary 1.5 volt flashlight cell, the instrument has an external means on the side of the case for adjusting for change in cell output so that accurate readings are always possible.

A few general applications are resistance measurements, locating open circuits, short-circuits and ground.

New Draft Control System

THIS Differential Draft control system, perfected by the Mason Regulator Co., of Boston, Mass., is of the instrument type to regulate the amount of air passing through the furnace in accordance with the natural draft of the stack and also the quantity of fuel consumed. In

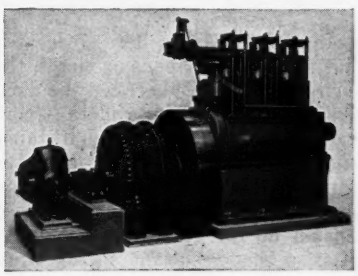


order to accomplish this, the instrument controls the feed of forced, or induced draft blowers, the inlet, uptake or stack dampers, or any other suitable means for controlling the flow of air to the furnaces. This instrument is operated by compressed air, with sensitive pilot operation so that even the slightest variation in draft differential is sufficient to control the blowers or dampers to maintain perfect combustion under varying conditions, thus avoiding smoke nuisance.

Improved Vertical Gas Engines

VERTICAL FOUR-CYCLE gas engines, covering a wide power range in a variety of cylinder combinations, is announced by the Worthington Pump and Machinery Corp., Harrison, N. J. These units are built with one to eight cylinders and 30 to 150 hp. per cylinder, covering power requirements from 30 to 1800-hp.

Among details of construction are: A mixing valve, common to all cylinders and adjustable through a single knurled handscrew, on all but the largest units; separate air and gas mixing valves independently adjustable for each cylinder, in each cylinder head of the largest engines; in all but the smallest units, air inlet and exhaust valves in removable and interchangeable cages, the exhaust valve cages being water cooled; in the smaller engines, these valves (also interchangeable and adjustable) seat directly in the cylinder head and operate in removable bushings; an attached reciprocating pump to circulate lubricating oil through a cast-in duct in the base with cast-in branches leading to the bottom of each main bearing; drilled passages in the crankshaft and connecting rods, to feed oil to crank and wristpin bearings under pressure from the main bearings; camshaft gear, governor and all other points requiring lubrication supplied with oil under pressure from

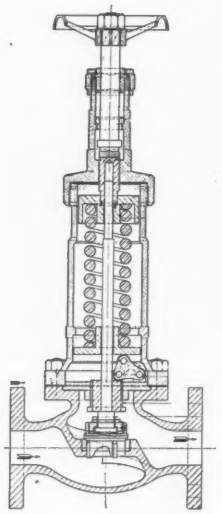


the flywheel end of the main oil duct; two-point force-feed lubrication of the cylinders on all but the smallest units.

Removable at right angles to the engine, the camshaft is driven from the flywheel end by spur gears with silent spiral teeth, a tight cover inclosing the entire camshaft assembly, including its lubrication. All essential points are cooled, flow of water in all jackets being so directed that there are no dead pockets. Cylinder liners and heads are readily cleaned through large handholes and access to main and crank bearings is gained through large doors in the front and rear. The manufacturers state that these engines can be readily converted to Diesels at moderate expense, fuel pumps and spray valves replacing magneto and spark plugs, mixing valves being omitted and Diesel cylinders, with smaller valves in the heads being substituted.

Oil Relief Valve with Compensator

IN THESE valves, made by Schutte & Koerting Co., Philadelphia, Pa., the principal feature is compensating mechanism with three links mounted on a link bracket, spaced at 120 deg. around the spindle. Ends of the links bearing on plug and



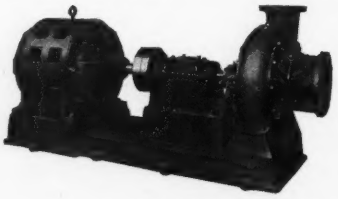
spring plate have rollers so located that as the valve opens or closes, the horizontal distance between the fixed centers and the lower rollers is constant, while the horizontal distance between the fixed center and the upper roller varies, the variation in leverage compensating for increased tension of the spring as the valve lifts, so that resultant spring pressure is equalized throughout the movement of the valve disc. Screw spindle adjustment is for a range of 15 to 600 lb. for free operation of the valve. Globe and angle types are made, with no moving part passing through a stuffing box; removal of bonnet nuts gives access for cleaning and inspection. Used for by-pass on fuel-oil burner or lubricating lines, these valves are stated to maintain constant discharge pressure, which can be readily adjusted as desired, with reduction in number of valves required and quiet action. For low-pressure steam lines, the valve is made with outside spring, compensating mechanism acting on the same principle.

Non-Clogging Centrifugal Pump

MORRIS MACHINE WORKS of Baldwinsville, New York, announces a new non-clogging centrifugal pump for handling pulp of both heavy and light consistencies.

Suction nozzle, impeller and pump passages are of special form to secure uniform conversion of the velocity of the material to pressure with minimum friction, slippage or separation of water from pulp.

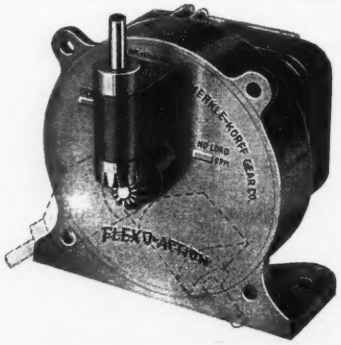
Impellers of various types and number of vanes have been designed for the different kinds and consistencies of stock. Open impellers are made with sufficiently strong vanes to handle rags, sticks and even



blocks of wood without breaking; enclosed impellers with wide passages, such that an 8-in. diameter ball will pass through the enclosed impeller of a 10-in. pump. Special impeller for exceptionally heavy pulp acts as a screw conveyor, for effective handling of the thickest stocks.

Speed Reducer for Controls

TO BE INCORPORATED as an integral part in temperature control apparatus, governors, automatic oilers, automatic draft apparatus recording instruments and automatic stop and check valves, a small speed reduction unit with an enclosed motor drive has been placed on the market by the Merkel-Korff Gear Co., 213 N. Morgan St., Chicago, Ill. Overall dimensions are height



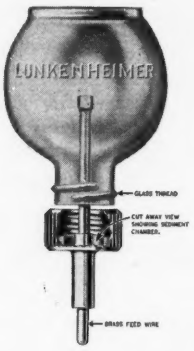
3⅛ in., width 3⅛ in., depth 2⅜ in. It is built for motor speed from 3000 r.p.m. downward, clock wise or counter clockwise rotation, in horizontal or right angle drive, the right angle drive being available with the output shaft in any position around the 360-deg. circle.

Induction motor of the shaded pole type or a synchronous motor is provided, or universal motor for d.c. applications.

Lunkenheimer Bottle Oiler

LUNKENHEIMER CO. is marketing a new design of Bottle Oiler, having glass bottle with threaded neck, bronze base with integral sleeve type shank, and brass feed wire. A thick resilient cork washer seals the joint between bottle and base. To supply the correct amount of oil for the economical lubrication of plain bearings, this is automatic in operation, feeding only when the shaft is in motion.

Two principles are involved in its action: What might be called Thermal Breathing, a periodic expansion and contraction of the air within the bottle due to changes in temperature; Capillary Creep aided by the agitation of the feed wire when the shaft is in motion. As



feed is slow, one filling lasts a long time and the supply is always visible. Ease of application, convenience of refilling and replacing empty bottle oilers with full ones, cleanliness, are some of the qualities which make this oiler useful in industrial plants.

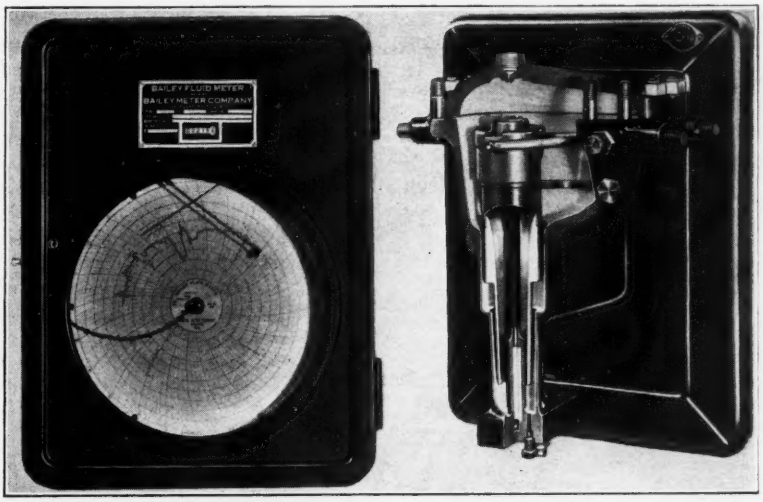
High Temperature Paint

LACLEDE CHRISTY CLAY PRODUCTS CO., St. Louis, Mo., is introducing Laclede C-10 High-temperature paint for miscellaneous industrial applications. The most refractory paint of this new line is the black which will withstand temperature of approximately 1800 deg. F.; other colors, red, green, gray and white, withstand temperatures ranging from 1000 to 1400 deg. F. The paint is shipped ready for application, of the same consistency as ordinary paint. Tests have shown suitability for boiler and furnace fronts, breechings, domestic heating equipment; gasoline engine exhaust manifolds, locomotive fronts, furnace doors, rotary kilns.

Bailey Fluid Meters

FOR THE MEASUREMENT of steam, water, gases and other fluids the Bailey Meter Co., Cleveland, Ohio, has developed a new line of meters of high accuracy and dependability.

Three general combinations are available: indicating and integrating; recording and integrating; indicating, recording and integrating. The recording and integrating meter, which is best suited to the majority of installations, records in pounds per hour, gallons per minute or any other desired units on a 12 in. diameter, 24-hour chart, having flow graduations uniformly spaced. Total flow is given by a 6-unit counter, located behind a window in the meter name plate.



Sectional view shows construction of the meter flow mechanism, operated by difference in pressure between inlet side and outlet sides of the orifice or other primary element inserted in the pipe line. Inlet, or higher pressure, is connected to the interior of the mercury sealed Ledoux Bell, while the outlet or lower pressure is applied to the exterior of the bell, which moves up or down as a frictionless piston, with changes in the differential pressure, the vertical movement being proportional to the change in the rate of flow. Guide links direct the bell in a definite path, an advantage when the meter is used as portable equipment. By means of a forked lever and spindle, motion of the Ledoux Bell is transmitted directly to the recording pen and integrator.

Features of special interest are: Permanent calibration assured by protection against sudden surges or reversals of flow; pressed steel moisture and dust proof case for mounting on wall or panel surface, or flush front on a panel as desired; auxiliary recorders for temperature, pressure, vacuum or draft easily installed in the case, recording on the same chart with the rate of flow; meters available for use under any commercial operating pressure.

New Stroboscopic Meter Standard

TO MAKE meter testing as simple as setting a timepiece, the Westinghouse Electric and Manufacturing Co. has developed a portable stroboscopic meter standard, that, it is claimed, brings laboratory accuracy into field testing, and can be used for making accurate comparison of disc speeds between any standard meter and test meter.

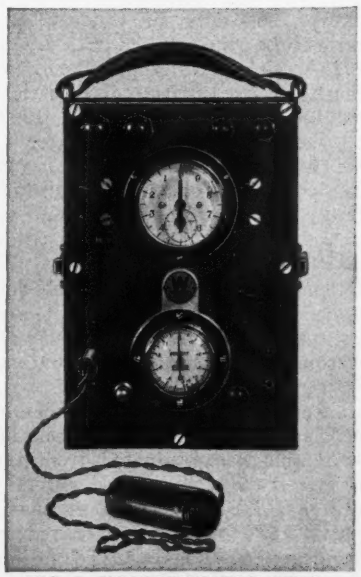


FIG. 1. NEW PORTABLE STROBOSCOPIC STANDARD SHOWING PER CENT ERROR DIAL AT BOTTOM OF PANEL

It consists essentially of a portable precision watthour meter complete with dials and pointers suitable for conventional meter testing and a stroboscopic equipment combined into an easily-carried unit. The case enclosing the standard is divided into two compartments, one containing the precision meter, an incandescent lamp, to serve as a light source and a photo-tube. The other compartment contains a power unit and amplifier connected to a Neon lamp through a flexible cord. The standard weighs only about 15 lb. net.

The stroboscopic principle of operation utilizes a uniformly rotating device, illuminated by a series of instantaneous flashes, appearing stationary if the rate of flashing is equal to the rate of rotation, moving forward if the rate of rotation exceeds that of the flashes and moving backward if the rotation is slower than the flashing.

To use the new standard, its meter element is connected in series with the meter under test, both being connected to the same load. The incandescent lamp in the tester is lighted and the Neon lamp is placed near the disc of the meter being tested so that its light strikes the disc. Light from the incandescent lamp 3 is broken into pulsations by passing through notches in the revolving disc 1 of the standard meter, these pulsations striking the photo-tube 4 and are transmitted

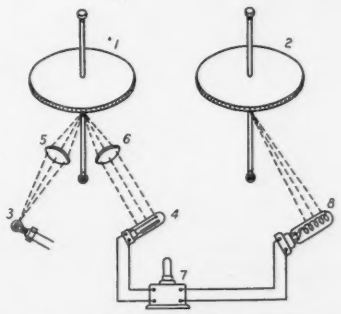
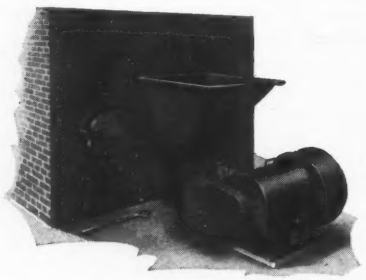


FIG. 2. DIAGRAM OF STROBOSCOPIC PRINCIPLE AS APPLIED TO THE PORTABLE STANDARD

to the Neon tube through the amplifier 7. The Neon tube 8 flashes in synchronism with the disc of the standard meter and the disc of the meter under test, 2, being seen in this flashing Neon light, appears stationary if it is in perfect synchronism with the standard meter. Thus to correct the meter it is necessary merely to adjust its speed until the disc appears to stand still.

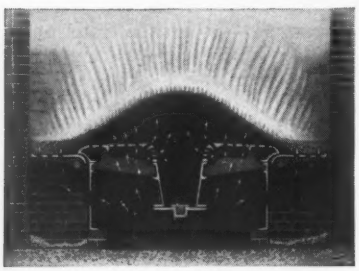
Detroit LoStoker

In the Detroit LoStoker developed by Detroit Stoker Co., Detroit, Mich., for the economical burning of coal, fuel is fed only when needed and equipment is automatically controlled.



This LoStoker employs the full underfeed principle to introduce the fuel below the burning zone. Gases, mixed with the correct quantity of incoming air, must pass through the hot fuel bed and are completely burned. Plunger feed gives positive operation and provides accurate control of the fuel bed.

By the side-cleaning feature, prior to dumping, air is admitted from the air chamber to the dumping grates to burn out the combustible. The dump lever then discharges



the ash and, after all dust has settled, it is removed through doors at the front.

Boilers now in use as well as new boilers can be equipped, few setting alterations being required and these easily made.

John R. Freeman

John R. Freeman, for many years an outstanding consulting engineer and consultant on hydraulic plants and plant economics, died recently at his home in Providence, R. I., at the age of 77 yr. Among the projects for which he did the engineering were control of the Merrimac River, of the Panama Canal and locks through Gatun Lake, the Los Angeles aqueduct and the development of the Hetch Hetchy water and power supply for San Francisco. He was also consultant on the Boston and the New York water supply systems and was an expert on fire protection systems. A graduate of Mass. Inst. of Technology, he served many years on its Board of Trustees. Honorary degrees of Doctor of Science were conferred on Mr. Freeman by Brown University, Tufts College, Saxon Technische Hochschule and University of Pennsylvania. Always interested in promotion of engineering knowledge, he was twice awarded the Normal medal for the best paper contributed to the Am. Soc. Civ. Engrs., was president of that society 1922-23 and of the Am. Soc. Mech. Engrs. 1904-05.

Rudolph F. Schuchardt

Rudolph F. Schuchardt, chief electrical engineer of the Commonwealth Edison Company, died in

Boston, Massachusetts, on October 25. Mr. Schuchardt was widely known not only in Chicago but throughout the United States, in 1928 occupying the presidency of the American Institute of Electrical Engineers. Since November, 1909, he was chief electrical engineer of the Commonwealth Edison Co. In this position he contributed substantially to the development of all phases of public utility generation and distribution systems. At the Commonwealth Edison Co. he had under his supervision all the electrical construction in stations and substations and on the distribution and transmission systems.

Rudolph Schuchardt was born in Milwaukee, Wis., on December 14, 1875 and was graduated from the University of Wisconsin with the degree of B.S. in electrical engineering in 1897, which was followed by the degree of E. E. in 1911 from the same school. In 1898 he entered the service of the Chicago Edison Co. in the testing department and advanced through all the grades until in November, 1906, he was appointed electrical engineer of construction.

Throughout his career in the electrical field, Mr. Schuchardt maintained an active participation in the work of national and local associations, both electrical and otherwise. In the American Institute of Electrical Engineers, he served in many capacities and on various committees and in 1928 was accorded the highest honor in the electrical industry, that of president of the Institute. He was past chairman of the Chicago section of the Illuminating Engineering Society; past chairman of the technical national section of the N.E.L.A.; chairman of the Power Survey Commission, and of many other committees of various organizations. He was a member of the Western Society of Engineers, and although he never held office he was active in committee work of this society throughout his membership. A former chairman of the American Engineering Council, in 1929 he was a delegate to the World Engineering Congress in Japan.

He is survived by a son and daughter.

Dr. Willis Rodney Whitney, organizer and for 32 yr. director of the research laboratory of the General Electrc Co., has retired from that position owing to poor health, but continues as vice-president in general charge of research. As his successor, Gerard Swope, president of the company, has appointed Dr. William David Coolidge.

The research laboratory was established in 1900 and Dr. Whitney took charge of the work, coming from Massachusetts Institute of Technology, where he was an instructor. The first work of the laboratory was done in an old barn which was then used by the late Dr. Charles P. Steinmetz as a private laboratory. A few months later the laboratory was given a small building at the General Electric works, one of the first laboratory achievements being a new type of incandescent electric lamp, developed by Dr. Whitney himself. Growth of the laboratory began with this work and it constantly expanded. In 1906 Dr. Whitney persuaded Dr. Coolidge to come to the laboratory.

Dr. Coolidge, the new director, is a native of Hudson, Mass., was trained at Massachusetts Institute of Technology and the University of Leipzig, appointed assistant director in 1908 and associate in 1928.

News From the Field

GEORGE OENSLAGER of the B. F. Goodrich Co. has been awarded for 1933 the Perkin medal given annually for the most valuable work in applied chemistry, one of the highest honors that can be received by an American chemist. Basis for the award is pioneering in development of organic accelerators for rubber vulcanization, resulting in great reduction in time and longer life of products. The medal is awarded by the American section of the Society of Chemical Industry on recommendation of a committee representing that society, Amer. Chem. Soc., Amer. Electro-Chem. Soc., Amer. Inst. Chem. Engrs. and Soc. de Chemie Indust. of France.

FOLLOWING THE MEETING of the Board of Directors of the Westinghouse Electric and Manufacturing Company, held in New York, President F. A. Merrick announced the election of two vice-presidents. C. E. Stephens, formerly commercial vice-president, with headquarters in New York was elected vice-president. He will remain in New York. N. G. Symonds, formerly commercial vice-president at Chicago was elected vice-president in charge of sales. His headquarters will be at the general offices of the company in East Pittsburgh. According to the announcement he will report directly to J. S. Tritle, vice-president and general manager.

J. SCOTT BUTTON, in charge of the architectural engineering service bureau of the General Electric Co., died at Schenectady November 3 following several weeks of illness with pneumonia. Entering the employ of the company in 1896, after attending Cornell University, he passed through engineering and commercial lighting departments to charge of sales to educational institutions and municipalities, thence to charge of the architectural engineering service bureau. He was first vice-president of The Producers' Council, associated with the American Institute of Architects, was a member of the commercial and industrial lighting committee of the N.E.L.A., was a member of the welding committee of the American Inst. of Steel Construction and was active in the work of other architectural organizations.

Mr. Button was a corporal with the 37th Co., National Guard, in the Spanish-American War, saw service on the Mexican border in 1916, and was overseas in the World War as a major in the 105th, and then 106th, Infantry of the 27th Division. He was buried with full military honors.

LINK-BELT Co. has appointed George M. Sharer sales manager of its eastern division, with headquarters in Philadelphia, with direct supervision of sales of all of the company's offices in the Atlantic Coast states.

J. E. MCFATE, formerly associated with Jones & Laughlin Steel Corp., has been appointed sales representative of Republic Steel Corp. in the New England territory, with headquarters in Boston.

KAYE & MAC DONALD, Inc., announce the appointment of Boig & Hill, Inc., 87 Barclay St., New York City as New York State representative.

GEORGE B. MULLOY has become a partner with Brady & McGillivray which will be known as Brady, McGillivray & Mulloy, Chicago, to conduct a consulting business specializing in reduction of fuel, electric, gas and water costs.

H. W. RINEARSON, vice-president of sales, A. M. Byers Co., Pittsburgh, Pa., announces the appointment of W. A. Taylor as division manager in charge of the Chicago office of the company, to replace M. G. Henderson, who has resigned.

COMBUSTION ENGINEERING CORP. announces that it will continue lending slide lectures on "Boilers" and "Fuel Burning Equipment for Modern Steam Plants" to any technical society, club or institution. The Boiler Lecture, traces from Hero's time, to the present, when steam is being produced at a rate greater than 1,250,000 lb. per hr by single units, illustrated with about forty slides. The Fuel Burning Lecture traces burning coal from small hand-fired boilers to central station pulverized-coal fired units, which burn up to 1000 tons of coal per day, illustrated with about fifty slides. In asking for reservations for the lecture sets, two tentative dates should be submitted to provide for some latitude in arranging a schedule.

EXHIBIT OF THE Brown Instrument Co., Philadelphia, at the New York Power Show, Booth 49, will show the new Brown Mechanical Flow Meter measuring flow through a pipe circuit, part of which is made of glass, so that the observer can see the flow through the orifice. The orifice plate itself is made of glass and the action of entrained air bubbles on either side of the orifice as the column of liquid rushes through, shows visually the conditions which produce the differential pressures on which the operation of the flow meter depends. A U-tube is set up and connected across the orifice to show this pressure differential and means are provided for varying the flow so that the relations between the flow and differential pressure can be readily demonstrated. The above display will occupy the central panel of a modern board containing four other sections, respectively featuring pyrometers, both the potentiometer and millovoltmeter types for stack and furnace temperatures; electric flow meters, for steam, water, air, oil and gas flows of indicating, integrating and recording, and strip chart models; recording gages for pressure, liquid, level, CO_2 and other miscellaneous factors in power plant efficiency. At the booth will be found R. P. Brown, president; George W. Keller, vice-president and general sales manager; C. H. Kerr, vice-president and general manager; J. P. Goheen, secretary-treasurer; R. D. Bean, chief engineer; M. M. Watkins, district representative in charge of the New York office.

SHARPLES Specialty Co., Philadelphia, will display at the New York Power Show its En Bloc oil purifiers for Diesel engine oil and lubricating oil and Vaportite super centrifuge for removing impurities from oil.

AT THE New York Power Show, Bailey Meter Co. in booths 50, 1, 4, 5, will display its new line of fluid meters with sectional model, drawings to show operation of its 3-element feedwater control and combustion control, also its dieform compression fittings for copper tubing on small service lines. H. M. Hammond, manager of sales and engineering, will be in charge.

DETROIT STOKER Co. will exhibit at the New York Power Show full size multiple retort stoker in operation in booth 73. Features of the design are inclined fuel bed from underfeed, large, square retorts fed by square rams; high, side-wall plate tuyeres; front-wall, sectional wind boxes and air zoning; moving extension grates at the rear of retorts, followed by dumping grates.

FOSTER WHEELER CORP. will exhibit at booths 77 and 91 at the New York Power Show typical turbine room and boiler room equipment, full size sections of radiant heat superheaters, B type water wall construction, wing back type water wall construction, in which the bare tubes of the wall are backed with iron castings, split ring floating head heat exchanger, full size sections of high-pressure and forged-steel boiler header, pulverized-fuel control device assembled for operation, together with other models, drawings and photographs covering expansion joints, hot-well pumps and lockhead, high-pressure heater construction.

EXHIBIT OF THE Republic Flow Meters Co. at the New York Power Show will feature the Republic Centralized Metering System which permits all essential records on one panel, centrally located irrespective of the distance from the measuring point. Also will be exhibited miniature reproductions of Republic Centralized Metering Systems, designed and built for several plants. New Republic Multiple Recording System, to produce coordinate records of flows, temperatures, pressures, vacuums, CO_2 percentages on a single, evenly divided strip chart will be shown and Republic CO_2 meters of both the mechanical and electrical recording and indicating type, the mechanical CO_2 indicator being on display for the first time.

NEW AUTOMATIC zeolite water softener will be shown by The Permutit Co. in booth 348 at the New York Power Show.

EXIDE batteries of various types will make up the New York Power Show exhibit of Electric Storage Battery Co.

YARNALL-WARING Co. will exhibit at the New York Power Show its Eye Line water level gage with distance indicator and automatic signal, in action and in sectioned model. Also Gun-Pakt expansion joints, new type tandem blowoff valves, floatless Hi-Lo water column, laminated packing and flat glass, mica-protected water gage inserts for high-pressure boilers.

IN BOOTHS 50, 1, 4, 5, Babcock & Wilcox Co. will have, at the New York Power Show, section of its light weight insulated casing, welding exhibits, stud tube construction for Bailey water-cooled walls, new mechanical and steam atomizing oil burners, alloy castings and tubes, with drawings and photographs of new small pulverizer and other equipment.

For the Engineer's Library

A NEW METERING SYSTEM combining the advantages of the new OC detachable watthour meter, the new portable stroboscopic standard, and the nofuze load center is described in Circular 1960 published by the Westinghouse Electric and Manufacturing Company, Newark, N. J.

STEEL CHAINS is the subject of a new 14-page illustrated catalog No. 1192 issued by Link Belt Co., Indianapolis, Ind. Specifications, dimensions, strengths and list prices are given for chains from 950 lb. strength to 1,500,000 lb. in all types. Attachment links, sprocket wheels and power tables are included.

BULLETIN of the D. O. James Mfg. Co., Chicago, Ill. describes its recently perfected flexible couplings for power drives.

S. MORGAN SMITH CO., York, Pa., in its bulletin No. 129 illustrates and describes the Leonard trash rack rake for removing obstructions from the racks at inlets to hydraulic tunnels.

INNERSEAL fittings as made by the Parker Appliance Co., Cleveland, Ohio, for use on copper plumbing lines are described, illustrated and their use and advantages shown in a catalog recently issued.

ARMSTRONG MACHINE WORKS, Three Rivers, Mich., is issuing a new manual on steam trap engineering, containing complete information on the Armstrong Inverted Bucket steam traps. Important chapters include: Why steam traps should be used, with tables of actual dollars cost of various sized steam leaks; how to determine size of trap required for medium, high, or fluctuating pressures and extra large volumes of condensate; how to calculate the rate of condensation in the various types of equipment where steam is used; installation and maintenance of traps.

ACCORDING TO Report 5 of the Federal Oil Conservation Board, of which R. L. Wilbur, Secretary of the Interior, is chairman, the American oil industry gives indications of being the first industry to emerge from the world depression. Crude-oil prices at the end of the first half of 1932, although near the border line of average production cost, are over twice the mid-continent levels of a year ago and five times the 1931 lows. Efforts are under way to stabilize domestic crude-oil production at about 2,000,000 barrels daily, which, if successful, will further strengthen the industry's condition. The report is a comprehensive review of the production, refining, marketing and reserve situation and can be obtained from the Superintendent of Documents, Washington, D. C., for $1.00 per copy.

FUSION WELDING in the power plant is rapidly gaining headway and the Hartford Steam Boiler Inspection & Insurance Co. of Hartford, Conn., are distributing a reprint of an article from their house organ, giving a short history of fusion welding and stating the attitude of the company on this development which is today playing such an important part in the power plant.

AS RESEARCH SERIES Bulletin No. 40, the Engineering experiment Station, Purdue University, Lafayette, Ind., has published the results of experimental work in the flow of water through circular, parabolic and triangular vertical notched weirs. General formulae and specific data on the various types of weirs are given in the form of tables and curves. This is an 82 page paper bound bulletin which sells for 50 cents,

BULLETIN on surface condensers issued by Ingersoll-Rand Co., 11 Broadway, New York, illustrates installations ranging from small units up to those of 160,000 kw. capacity. Features discussed in its 36 pages include single- and two-pass construction, heart-shaped shell, external air coolers, longitudinal steam distribution and tube-sheet arrangement. Separate sections are devoted to small steel-plate and marine condensers.

PIPE BENDING is discussed at length in bulletin No. 50 issued by A. M. Byers Co., Clark Bldg., Pittsburgh, Pa. It shows what occurs in the metal during bending, effect of bend curvature and pipe diameter, proper method of bending and minimum allowable bend diameters for various pipe diameters. Advantages of Byers Genuine Wrought Iron Bending Pipe, a new development, are given.

MASON Differential Draft Control system is described by Mason Regulator Co., 1190 Adams St., Boston, Mass. in a new catalog just issued.

TYPE O "DE-ION GRID" oil circuit breakers are described in Circular 1958 recently published by the Westinghouse Electric and Manufacturing Company. These breakers are for indoor service in voltages from 15,000 to 34,500 and interrupting capacities from 500,000 to 2,500,000 kv-a.

Two other publications issued by Westinghouse are devoted to lighting equipment, No. 219A, on Industrial lighting equipment and 219B on Commercial Lighting. They are 64 and 44 page booklets respectively and list complete lines of lighting equipment.

IN an attractive 24-page bulletin, No. 300, published by the Bailey Meter Co., Cleveland, Ohio, is described the new line of Bailey Fluid Meters now available. This bulletin describes and illustrates the several types of meters which can be furnished, and points out the distinctive features of the new line. Other sections of the bulletin deal with the application and methods of installation of the equipment. Numerous illustrations are included comprising detailed drawings, diagrammatic sketches, equipment photographs, installation photographs, and chart reproductions in four colors.

DETAILS of a new 30-amp., 1-hp. disc switch for front operation are given in a bulletin, Catalog 90211, issued by the Square D Co., Detroit, Mich.

ISSUED BY the Air Preheater Corp., Wellsville, N. Y., a new bulletin compares the value of various sections of heating surface in a boiler installation and raises the question, "Why buy boiler heating surface that cannot do much work?" Advantages of heat recovery by preheating air and the effect of the Ljungstrom heater on heat economy are shown.

IN THE October issue of Nickel Cast Iron News, writing on the life of pumps, E. H. Huss of the Viking Pump Co. states that to obtain a gray iron suitable for pump castings to handle liquids carrying suspended matter tests were made and it became evident that iron having a hardened matrix supporting the hardened carbide was best suited to long wearing service. "It is well known that nickel, being soluble in iron, hardens and strengthens the ferrite matrix, also that chromium with a certain amount of iron forms the double carbide of iron and chromium. Just enough chromium should be included to stabilize the carbide as, with too much the carbide becomes friable, actually breaking up so that minute particles of carbide increase the abrasive effect. By right use of nickel and nickel-chromium additions to iron, foundry difficulties were eliminated, also pump life and efficiency were increased."

In another article on Metallography, the influence of silicon upon the carbon in cast iron is discussed and still other articles deal with use of nickel cast iron for large elevator sheave drums in the Rockefeller Center, for automobile brake drums, for Diesel engine castings and for automobile engine valve seats.

LACLEDE Mullite refractory characteristics are described and some results of use given in a bulletin issued by Laclede-Christy Co., St. Louis, Mo.

REPUBLIC STEEL CORP., Youngstown, Ohio, has issued a new price card, effective October 1, 1932, on Toncan Copper Molybdenum Iron Pipe, which embodies a simplified method of computing prices.

CONVEYOR BELT problems and the question of handling of many types of materials are discussed in How Shall We Handle It, a recent publication of the Diamond Rubber Company, Inc., Akron, Ohio.

HARNISCHFEGER CORP., 4400 W. National Ave., Milwaukee, Wisconsin, has just issued a new catalog called Weld It Well, on the latest developments in welding practice and welder design and describing new models of P&H Hansen Arc Welders.

PROPELLER PUMPS, which are axial flow pumps for handling relatively large volumes of liquid against comparatively low heads at high rotative speeds, so designed that the liquid flows through the pump in smooth lines without abrupt turns or change of direction, built for installation with the shaft either horizontal or vertical, and available for all capacities and for heads up to about 40 ft., are described in Catalog B-6, distributed by the De Laval Steam Turbine Co., Trenton, N. J.

TESTING SIEVES for determining the proportions of fineness of powdered and granulated material are described in a folder of Newark Wire Cloth Co., Newark, N. J.

LINK-BELT Book No. 1457 is a list price and catalog of 264 pages covering Silverlink chains for driving and conveyors, with attachments and applications, issued by Link-Belt Co., 501 No. Holmes St., Indianapolis, Ind.

Power Plant Construction News

Ariz., Phoenix—Verde River Irrigation & Power District, Security Building, Phoenix, W. H. Bartlett, secretary, plans construction of four hydroelectric power plants, number of power substations, transmission and distributing lines, with series of electric-operated pumping plants and auxiliary mechanical units, in connection with proposed Verde River irrigation project. Project estimated to cost about $16,000,000,

Ark., Malvern—Rock Port Minerals, Inc., Malvern, R. H. McKnight, president and manager, plans installation of electric power equipment in proposed rutile and other mineral products concentrating mill on site near city. Entire project reported to cost close to $75,000.

Calif., San Francisco—Construction Service, Veterans' Administration, Washington, D. C., will receive bids until Dec. 20, for buildings and utilities for institution at San Francisco, including boiler plant equipment, steel stack, refrigerating and ice-making plant, electric and hydraulic elevators.

Calif., San Francisco—Pacific Gas & Electric Co., 245 Market Street, is arranging a fund of about $5,000,000 for extensions and improvements in power plants and system, including gas plants and distribution lines, during next 12 months, including installation of considerable equpment. Company engineering department will be in charge.

Colo., Olney Springs—Twin Lakes Reservoir & Canal Co., Olney Springs, plans installation of power, pumping and auxiliary mechanical equipment in connection with extensions and improvements in water system. Financing in amount of $1,125,000 has been arranged for project.

Ga., Macon—City Council has surveys and estimates of cost in progress for a municipal electric light and power plant. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Ill., North Chicago—City Council will have surveys and estimates of cost made for a municipal electric light and power plant. Michael Opeka, city clerk, will engage engineer for work

Ind., Brazil—City Council is having plans completed for a municipal electric light and power plant. Estimated cost not announced. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Iowa, Centerville—Iowa Southern Utilities Co., Centerville, has made application for permission to construct a transmission line in Decatur, Wayne and Lucas Counties, totaling about 50 miles, with power substation facilities. Company engineering department is in charge.

Iowa, Corning—At a special election, citizens have authorized City Council to arrange for fund of $160,000, for construction of a municipal electric light and power plant. Plans will soon be completed. Vincent J. Mack, city clerk, in charge.

La., New Orleans—Board of Trustees, Dillard Memorial University, plans construction of a power plant with new group of university buildings. Entire project will cost over $175,000. Proposed to ask bids near close of year. Moise H. Goldstein, American Bank Building, New Orleans, is architect.

Mich., Bessemer—Underwood Veneer Co., Wausau, Wis., will build a one-story power plant at new saw mill and lumber plant at Bessemer. Entire project reported to cost over $50,000, with equipment. O. C. Lemke is president.

Mich., Detroit—Department of Public Works, City Hall, L. G. Lenhardt, commissioner, plans installation of power equipment, conveying and loading, and other mechanical equipment in new municipal refuse and garbage incinerator plant, entire project estimated to cost more than $1,500,000. Bids will soon be asked, closing early in January.

Mich., Ludington—City Council is having surveys and estimates of cost made for a proposed municipal electric light and power plant. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Mo., St. Louis—St. Louis-Kansas City Short Line Railway Company, care of E. H. Lawson, 505 Main Street, St. Joseph, Mo., president, plans construction of an electric railway line between Kansas City, Mo., and St. Louis, double track, about 236 miles, with power stations, substations, and transmission.

N. J., Atlantic City—Atlantic City Electric Co. has authorized construction of underground power lines in number of streets, replacing present overhead system. Work is estimated to cost about $600,000, with equipment. Company engineering department is in charge.

N. Y., New York—American Foundation Co., 565 Fifth Avenue, has secured a contract from the Government of Latvia, Riga, for construction of a hydroelectric generating plant on the Duna River, with power dam, power substations, transmission lines and other structures, at price of about $5,000,000. Contracting company will purchase equipment for project.

Ohio, Cincinnati—Lackman Brewing Co., care of H. Albert Lackman, 4365 Carnation Place, recently formed by Mr. Lackman and associates, plans installation of electric power equipment, tanks, conveying and other mechanical equipment in new brewing plant on Southside Avenue, Riverside district. Entire project is estimated to cost about $200,000. Carl J. Kiefer, Schmidt Building, Cincinnati, is engineer.

Ohio, Galion—City Council has preliminary plans under way for extensions and improvements in municipal electric light and power plant. Estimated cost more than $125,000, with equipment. Hadlow, Hughes, Hicks & Conrad, Citizens Building, Cleveland, Ohio, are consulting engineers, in charge.

Okla., Hominy—City Council is considering a proposition tendered by Trans-American Construction Co., Philtower Building, Tulsa, Okla., to construct a municipal electric light and power plant, estimated cost $135,000, with equipment. V. V. Long & Co., Colcord Building, Oklahoma City, Okla., are consulting engineers.

Okla., Tahlequah—Purchasing Office, Department of Interior, Washington, D. C., will receive bids until Dec. 8 for steam power house and underground steam distribution system, for central heating service at Sequoyah Training School, Tahlequah, as per plans on file.

Ore., Hillsboro—City Council plans installation of pumping machinery and auxiliary mechanical equipment in connection with proposed municipal water system. Entire project will cost close to $300,000. Barr & Cunningham, Spalding Building, Portland, Ore., are consulting engineers.

Pa., Carlisle Barracks—Constructing Quartermaster, Carlisle Barracks, Carlisle, will receive bids until Dec. 7, for steam power plant for central heating service, as per plans on file.

Pa., Farmers Valley—Quaker State Oil Refining Corporation, Oil City, Pa., plans installation of electric power equipment, pumping machinery, tanks and other equipment in connection with expansion and improvement program at oil refinery at Farmers Valley, entire project to cost over $300,000.

Texas, El Paso—McNutt Oil & Refining Co., El Paso, plans installation of power equipment, pumping machinery, tanks and other mechanical equipment in proposed new oil refining plant on local site, entire project reported to cost close to $100,000.

Texas, Fort Worth—Sinclair Refining Co., Fort Worth, plans installation of power equipment, air compressors, pumping machinery, tanks and other mechanical equipment in connection with expansion and improvement program at local oil refinery, entire project to cost about $650,000. Headquarters are at 45 Nassau Street, New York, N. Y.

Va., Emporia—Interstate Veneer Co., Emporia, plans installation of electric power equipment in connection with proposed rebuilding of panel mill, recently destroyed by fire. Loss over $75,000, including equipment.

Va., Fredericksburg—Sylvania Industrial Corporation, 122 East Forty-second Street, New York, N. Y., plans installation of electric power equipment in new additions to transparent cellulose material manufacturing plant at Fredericksburg. Entire project will cost about $125,000. Ballinger Co., Twelfth and Chestnut Streets, Philadelphia, Pa., is architect and engineer.

Va., Radford—Appalachian Electric Power Co., Roanoke, Va., has secured permission to proceed with construction of new hydroelectric generating plant on New River, Pulaski County, near Radford, where work on power dam was started several months ago. Plant will be equipped for capacity of 26,000 hp., divided into four generating units, and will cost about $10,000,000,

Wis., Milwaukee—Theodore Hamm Brewing Co., Milwaukee, is considering installation of power equipment, tanks, kettles and other mechanical equipment in connection with an expansion and modernization program. Entire project is estimated to cost over $400,000. William Hamm, Jr., is president

Wis., Milwaukee—Bids will be taken soon in connection with the rehabilitation of heating and ventilating systems of public garage located at 1022 North 4th St., Milwaukee, Wis. Elsie Busby Estate, owners. Ottomar H. Henschel, Milwaukee, Wis., consulting engineer.

Machinery, Equipment and Supplies Used In The Production, Transmission and Utilization of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear

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De Laval Steam Turbine Co.
Foster-Wheeler Corp.
General Elec. Co.

Air Preheaters
Air Preheater Corp.
Babcock & Wilcox Co.
Edge Moor Iron Co.

Air Seals, Kiln
Edge Moor Iron Co.

Anti-Corrosive Coatings
Dampney Co. of America

Arches, Boiler and Combustion
Carborundum Co.

Ash Bin Gates and Doors
Allen Sherman Hoff Co.

Ash Handling Systems
Allen Sherman Hoff Co.

Bearings
National Tube Co.

Belt Dressing
Dixon Crucible Co., Jos.

Blowers, Fan and Furnace
Air Preheater Corp.
Carling Turbine Blower Co.
De Laval Steam Turbine Co.
Wing Mfg. Co., L. J.

Blowers, Forced Draft, Portable, Pressure and Pulverized Coal
Carling Turbine Blower Co.
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Blowers, Turbine
Carling Turbine Blower Co.
Elliott Co.
Moore Steam Turbine Corp.
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Boiler Blow Down Systems
National Aluminate Corp.

Boiler Coatings
Brooks Oil Co.
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Boiler Settings
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Boilers, Waste Heat
Babcock & Wilcox Co.
Edge Moor Iron Co.
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Brushes, Graphite, Dynamo & Motor
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Allen Sherman Hoff Co.

Coal Bunkers, Cast Iron Catenary
Allen Sherman Hoff Co.

Coal Crushers
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Ideal Commutator Dresser Co.

Commutator Dressers, Slotters, Stones
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Condenser Tube Cleaners
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Cooling Systems
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Cooling Towers
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Counters, Revolution
Lonergan Co., J. E.

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Terry Steam Turbine Co.

Couplings, Union
Dart Mfg. Co., E. M.

De-aerators
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Elliott Co.

Dryers, Coal
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Engines, Steam
Elliott Co.
Murray Iron Wks. Co.
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Hoppes Mfg. Co.
National Pipe Bend. Co.
Scaife & Sons Co., Wm. B.

Feed Water Treatment
Dearborn Chemical Co.
Hagan Corp.
National Aluminate Corp.
Permutit Co.
Scaife & Sons Co., Wm. B.
Zeolite Chemical Co.

Filters, Oil
Burt Mfg. Co.

Filters, Water
Cochrane Corp.
Permutit Co.
Scaife & Sons Co., Wm. B.
Zeolite Chemical Co.

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Carborundum Co.

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Hercules Float Works

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Flue Cleaners
Pierce Co., Wm. B.

Flue Gas Analysis Instruments
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Allen Sherman Hoff Co.

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Foster-Wheeler Corp.

Furnace Fire Observers
Springfield Boiler Co.

Furnaces, Boiler
Kennedy-Van Saun Mfg. & Engrg. Corp.

Furnaces, Pulverized Coal
Kennedy-Van Saun Mfg. & Engrg. Corp.

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Smooth-On Mfg. Co.

Gauge Cocks
Lonergan Co.

Gauges, Draft, Liquid Level
Bailey Meter Co.
Brown Inst. Co., The.
Pierce Co., Wm. B.
Republic Flow Meters Co.

Gauge Glasses
Jenkins Bros.

Gauges, Pressure and Recording
Lonergan Co., J. E.

Gauges, Water
Lonergan Co., J. E.
Lunkenheimer Co.

Gauge Testers
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Gears, Reduction and Double Helical
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Moore Steam Turbine Corp.
Terry Steam Turbine Co.

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Squires Co., C. E.

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Grating, Steel
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Irving Iron Wks. Co.
Tri-Lok Co.

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Dearborn Chem. Co.
Dixon Crucible Co., Jos.
Texas Co.
Tide Water Oil Sales Corp.
Vacuum Oil Co.

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Scaife & Sons Co., Wm. B.
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Yarnall-Waring Co.

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Dearborn Chem. Co.
Dixon Crucible Co., Jos.
Texas Co.
Tide Water Oil Sales Corp.
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Republic Flow Meters Co.

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Hoppes Mfg. Co.
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Pumps, Boiler Feed
De Laval Steam Turbine Co.
Moore Steam Turbine Corp.
Warren Steam Pump Co.

Pumps, Centrifugal
De Laval Steam Turbine Co.
Moore Steam Turbine Corp.
Warren Steam Pump Co.

Pumps, Elevator, Fire and General Service
De Laval Steam Turbine Co.
Warren Steam Pump Co.

Pumps, Hydraulic Pressure
Warren Steam Pump Co.

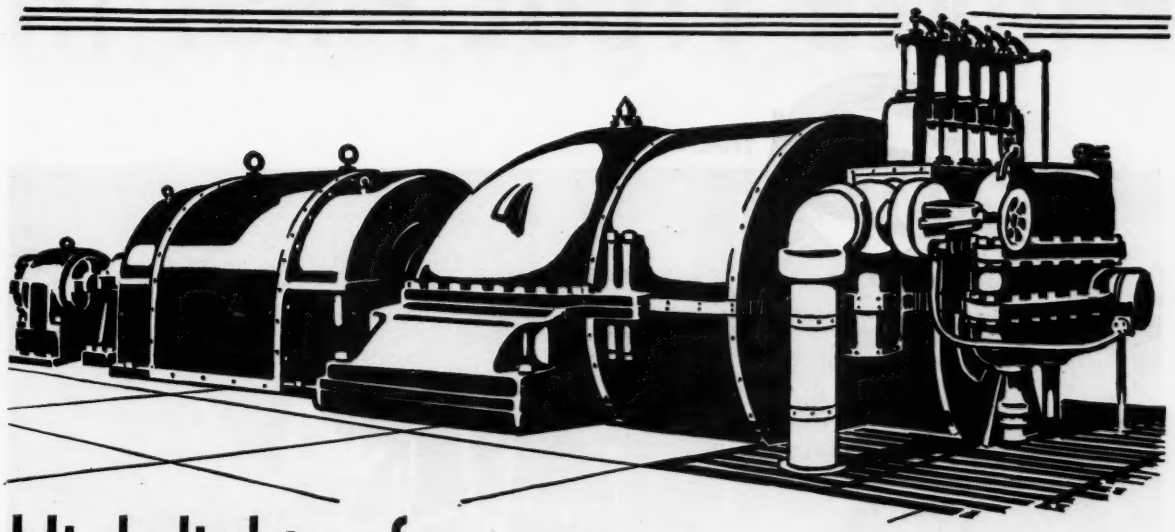
Pumps, Oil and Electric
Lonergan Co., J. E.
Manzel Bros. Co.
Warren Steam Pump Co.

Pumps, Power and Electric
Warren Steam Pump Co

Pumps, Turbine
Moore Steam Turbine Corp.

Pumps, Vacuum
Warren Steam Pump Co.

Engineers who know, call this a BETTER Turbine-Generator



High-lights of ELLIOTT TURBINE-GENERATORS

Four-Bearing Construction:
Turbine, generator and exciter each have two bearings —flexible couplings between units, assuring alignment, accessibility, freedom from vibration.

Five Governor-Operated Steam Admission Valves:
Moving individually in both directions by their own power cylinders—giving economy over wide load range and fast, positive, trouble-free governing.

Stream Line Exhaust Flow:
Reducing pressure loss between turbine and condenser—increasing efficiency.

Liberal Design:
Elliott engineers have not slighted a single detail in design, workmanship or material to make this the best turbine-generator unit for industrial plants, municipal plants and smaller central stations.

Let's check these and many more potent reasons why you should be fully informed on Elliott turbine-generator units. Bulletin H-7 will be sent on request, and a sales-engineer will gladly talk turbines with you—and no obligation on your part.

ELLIOTT COMPANY

PITTSBURGH, PA.

Steam Turbine Department JEANNETTE, PA.

District Offices in Principal Cities

H-576

TIDE WATER *Tests* 12

PROVES TYCOL FIRST IN

INDUSTRIAL TYCOL OILS-GREASES

TIDE WATER

■ *In the Tide Water laboratory, 15 control tests guard Tycol quality. The illustration shows how the stop watch is used to determine viscosity to the fraction of a second.*

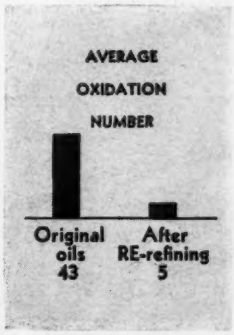
KNOW YOUR OILS

So sure is Tide Water of Tycol superiority, that it is making an unprecedented offer to buyers of turbine and Diesel oils. Tide Water will be glad to *re-refine for you*, by its Edeleanu Process, a sample of the turbine and Diesel lubricating oils you are now using. Not only that, Tide Water will welcome the presence of your own technologists, at the time.

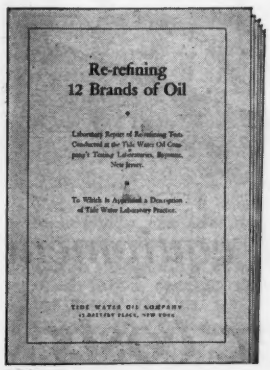
Competitive Oils by RE-*refining*

LUBRICATING VALUE

This Laboratory Report gives complete test-data and explains facts important to every user of turbine and Diesel oils.



When you buy turbine and Diesel oils, you are buying lubricating performance. You have every right to expect stability, long-life, minimum acidity, absence of sludging tendency.


Re-refining
12 Brands of Oil

TIDE WATER OIL COMPANY
17 BATTERY PLACE, NEW YORK

Naturally, you can't get these properties in oils containing from 9.8% to 25.3% (by volume) of impure extract. You can't get them in oils with oxidation numbers ranging all the way up to 194!

You would say that such oils are not being offered. But Tide Water bought in the open market 12 leading brands of oils, and gave them the *re*-refining test. That is, Tide Water *re*-refined them by the Special Edeleanu Process used to refine Tycol Turbine and Diesel Oils.

And the findings are exactly as stated above. An average of 16% impure extracts was re-refined out of these oils! The average oxidation number was lowered from 43 to 5!

PROPER REFINING THE KEYNOTE

The Laboratory Report goes into detail about all this. And it proves conclusively that PROPER refining is the keynote of good oil . . . that Tide Water's Special Edeleanu Process produces an oil of maximum stability and lubricating value.

Briefly, the reasons are: The Process is a physical solvent treatment. It dissolves ALL unstable hydrocarbons, found even in the best of crudes. It starts NO chemical reaction upon the components of oil, stable or unstable. It forms NO new unstable substances. And it preserves the pure and stable hydrocarbons of highest lubricating value.

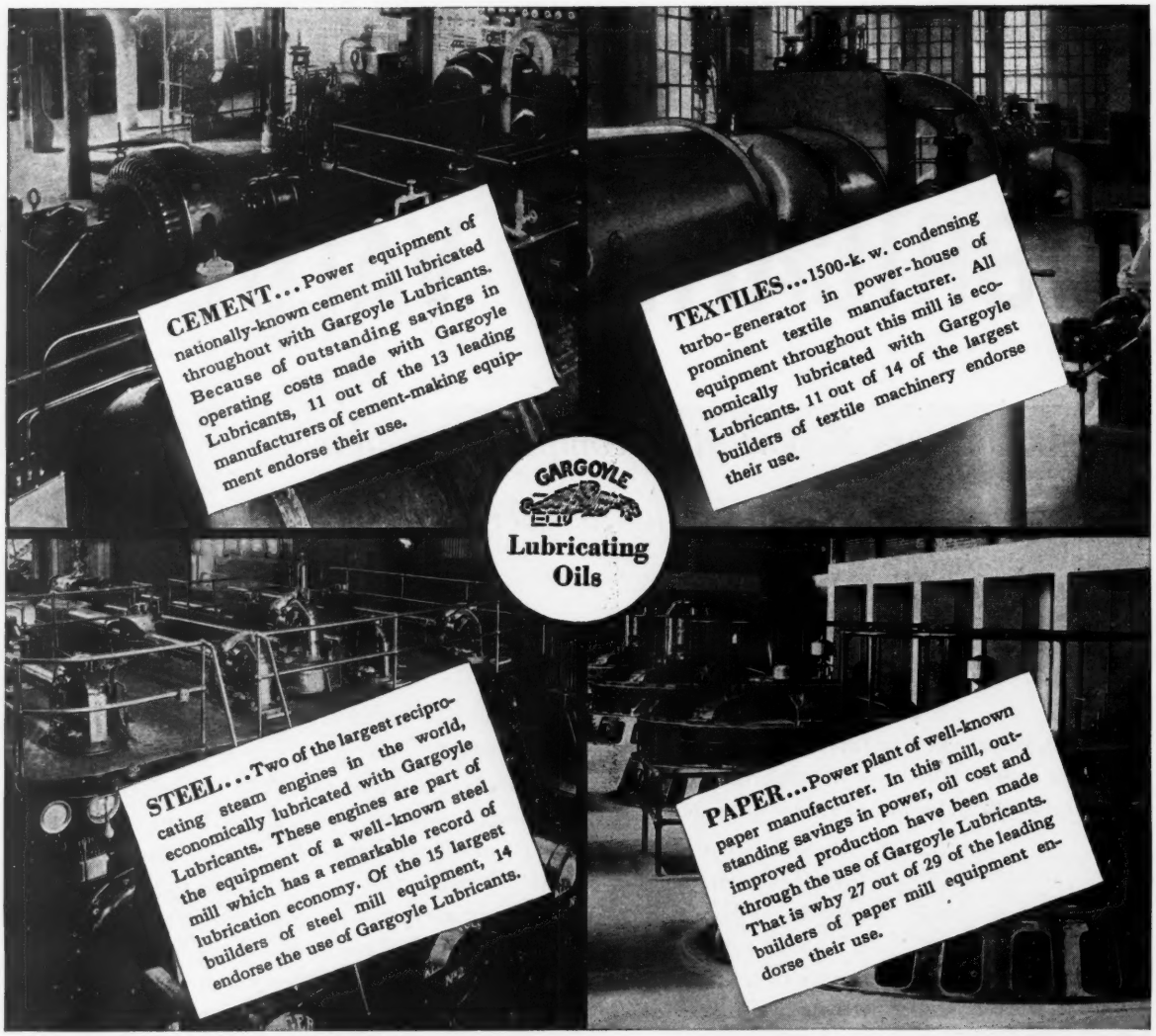
That is why Tycol Turbine and Diesel Oils, being 100% paraffine base, and refined by this Process, have purity and stability which no other oils possess. Tycol Oils have oxidation numbers ranging from 1/4 to 1/50 of those of competitive grades.

BE GUIDED BY SERVICE RECORDS

In the final analysis, it is service that counts. Everything shown in these laboratory tests is borne out by experience. Tycol oils have set up new records of performance for some of the country's leading producers of power.

Based on these records, you can depend on Tycol oils for low acidity, low carbon deposition and better demulsibility. You can depend on them for stability, for non-sludging, long-lasting, efficient, economical lubrication!

If you are interested in lubricating efficiency, by all means send for the Laboratory Report, "Re-refining 12 Brands of Oil." Address Tide Water Oil Sales Corporation, 17 Battery Place, New York.


CEMENT... Power equipment of nationally-known cement mill lubricated throughout with Gargoyle Lubricants. Because of outstanding savings in operating costs made with Gargoyle Lubricants, 11 out of the 13 leading manufacturers of cement-making equipment endorse their use.
TEXTILES... 1500-k. w. condensing turbo-generator in power-house of prominent textile manufacturer. All equipment throughout this mill is economically lubricated with Gargoyle Lubricants. 11 out of 14 of the largest builders of textile machinery endorse their use.
GARGOYLE
Lubricating Oils
STEEL... Two of the largest reciprocating steam engines in the world, economically lubricated with Gargoyle Lubricants. These engines are part of the equipment of a well-known steel mill which has a remarkable record of lubrication economy. Of the 15 largest builders of steel mill equipment, 14 endorse the use of Gargoyle Lubricants.
PAPER... Power plant of well-known paper manufacturer. In this mill, outstanding savings in power, oil cost and improved production have been made through the use of Gargoyle Lubricants. That is why 27 out of 29 of the leading builders of paper mill equipment endorse their use.

In every industry . . . in every type of equipment

Gargoyle Lubricants *lower costs*

Steel . . . cement . . . paper . . . textile . . . these are only a few of the industries in which Gargoyle Lubricants are cutting costs every day in actual operations.

Throughout the world, in every industry, Gargoyle Lubricants are daily making new economy records in the form of lower oil costs, lower power consumption, reduced maintenance expense and improved production.

Whatever type of equipment you operate, we can show you actual cost-cutting records made with Gargoyle Lubricants in equipment like yours operating under similar conditions.

Every possible economy is important now that increased production seems to be in sight. Now is the time to ask a representative to suggest means by which Gargoyle Lubricants can help lower your operating costs.

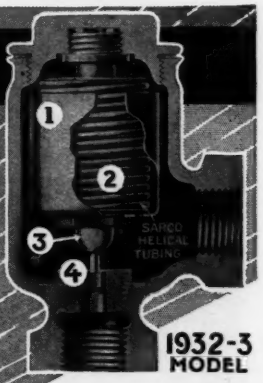
VACUUM OIL COMPANY, INC.

A SOCONY-VACUUM COMPANY

26 Broadway, New York City • Branches and distributors in principal cities throughout the world

STEAM TRAP PROGRESS

In spite of trends and fashions in steam traps during the past twenty years, Sarco has held fast to the thermostatic principle, because it is right. Some of its advantages are—no air binding or freezing; only one moving part; no losses from radiation or intermittent action; easiest installation and lowest cost of upkeep. If steam enters into the manufacture of your product, you have a golden opportunity to effect economies which will add dollars to your net profits. Let us send you information on the Sarco system of unit trapping (a trap on every coil) which is earning profits in thousands of plants.



1932-3 MODEL

THIS WAS A GOOD TRAP BUT — NOTE THE DIFFERENCE

1. This patented shield protects element against water hammer and steam abrasion.
2. New annealing process guarantees a tubing of uniform strength. Double length bellows reduces strain—doubles the life of the traps.
3. This patented lateral-moving valve head is self-centering. Seats in any position.
4. Valve head and seat are of stainless steel, scientifically formed to guarantee tightness at full pressure.

Write for Catalog B-95 and 30-day free trial offer.

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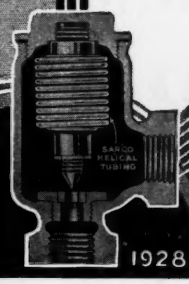
See Our Exhibit Booth 33 Power Show



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DIXON'S FLAKE GRAPHITE

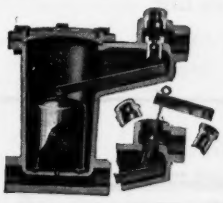
for better lubrication

For more than a century DIXON has pioneered in applying the advantages of natural flake graphite to the problems of lubrication.

Dixon's Graphite Products have each been developed for a specific service, for better lubrication, for longer service.

Consult DIXON on your lubrication problems.

JOSEPH DIXON CRUCIBLE COMPANY
Jersey City, N. J.



Who Can

blame engineers for not inspecting steam traps? Breaking into hot steam lines to inspect trap valves is eliminated with BUNDY INVERTED BUCKET TRAPS. Learn about their many desirable features.

Write today for Bundy details

THE BUNDY STEAM TRAP CO.
NASHUA, N. H., U. S. A.

The New MANZEL Force Feed Lubricator "Model 25"

For lubricating cylinders and bearings correctly and economically.

Delivers oil of any viscosity at the desired rate positively against high or low pressure.

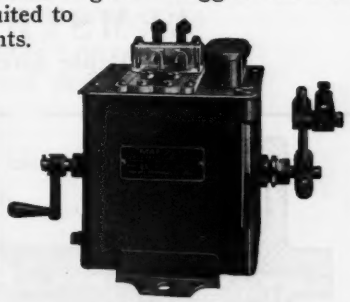
Easy to install — convenient to operate — extremely accessible.

Requires a minimum of attention.

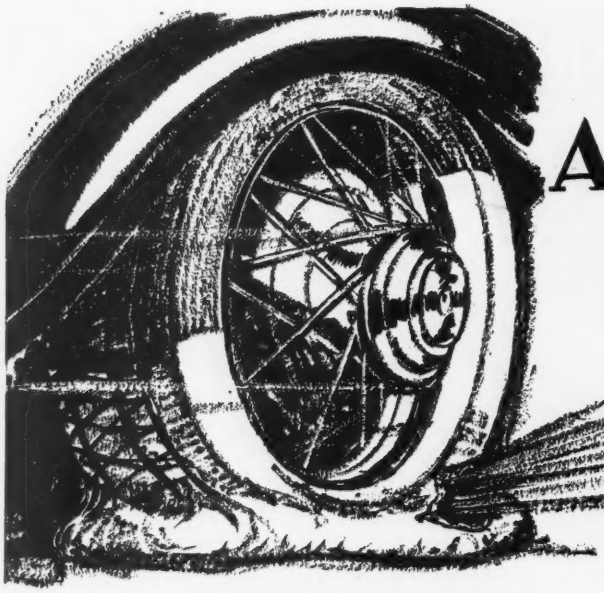
Adapted to a wide variety of installations.

Our engineers will be glad to suggest the size and type best suited to your requirements.

Catalog No. 31 Contains Full Details, Write for it.



MANZEL BROTHERS COMPANY
327 Babcock St., Buffalo, N. Y.



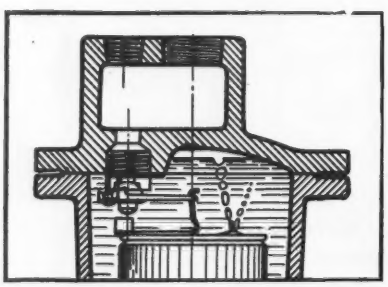
Get the AIR-REMOVAL CAPACITY of a "Blowout" with a new ARMSTRONG TRAP thermic vent

THE exclusive Armstrong development shown at the right below will vent air many times as fast as the ordinary steam trap. Almost any desired air removal capacity can be provided.

The standard Armstrong Trap vents air automatically as shown at the lower left and for most types of service this arrangement is entirely satisfactory. The thermic vent is added when submerged coils, unit heaters, jacketed kettles, hospital sterilizers, greenhouse radiation, steam heated cylinders in paper or textile mills, or other similar installations require the extremely rapid elimination of a very large volume of air.

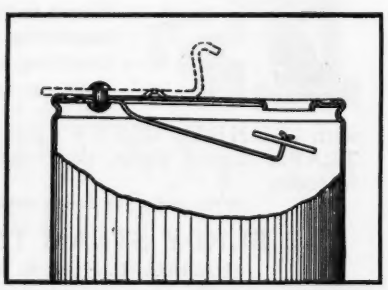
If you have a problem in venting air take it up with the Armstrong representative or write us. The new Armstrong thermic vent offers a standard of service on such jobs never before available.

ARMSTRONG MACHINE WORKS
810 Maple Street — Three Rivers, Michigan

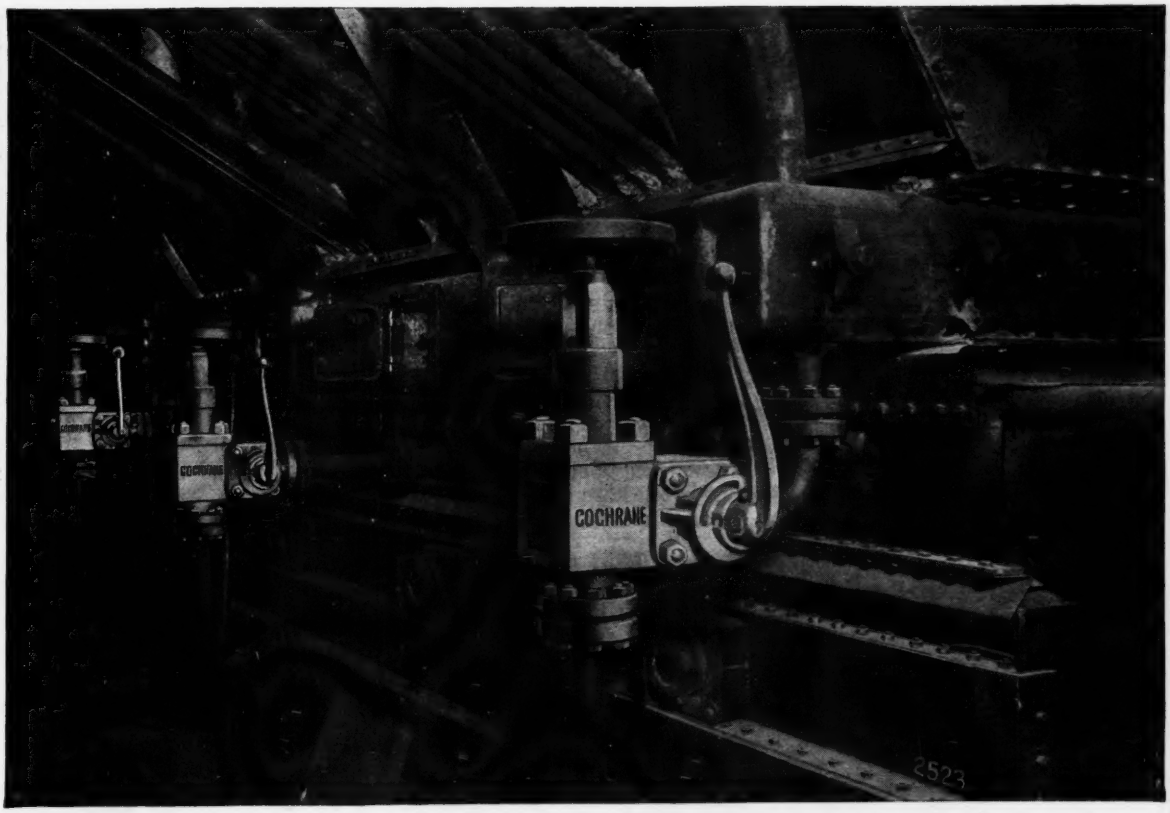


AT LEFT: The air vent in the top of the inverted bucket in an Armstrong Trap prevents air binding. Any steam that passes through the small standard vent is condensed to make up for radiation loss from the trap.

AT RIGHT: The large vent is closed by a flat disc fastened to the end of a strip of thermic metal. When the trap is cold the vent is open as shown allowing air to pass through so rapidly that the bucket cannot float and the discharge orifice therefore cannot be closed. As the temperature in the bucket rises, the bending of the thermic strip closes the vent and the trap functions in the normal manner.



PPE-12-Gray



Boiler Blow-Off Valve

for ANY pressure

COCHRANE Forged Steel Tandem Blow Off Valves have been in operation for over 5 years, under pressures up to and including 1800 lbs., in some cases operated every 2 hours, without leakage and without requiring regrinding or renewals.

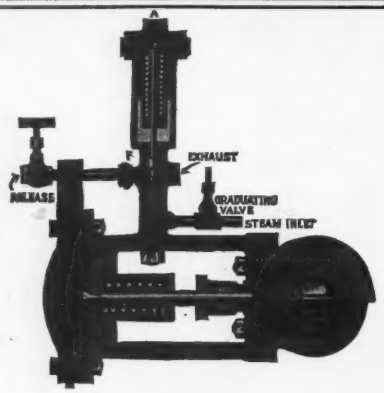
The secret of this unique performance is to be found in the fact that the SEALING SURFACES (rotary gate and main screw down valve) open and close only when there is no flow, hence are protected from wire drawing and erosion. The rotary gate valve is raised from its seat entirely while being turned, and the main screw down valve is protected by an auxiliary check valve which takes the punishment of opening and closing under pressure and flow conditions.

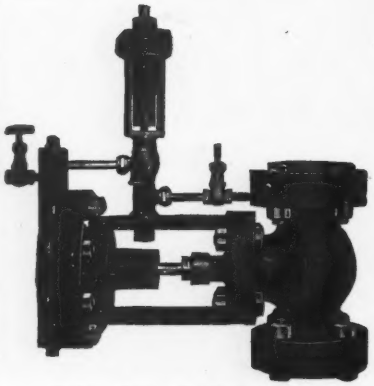
Inquiries are solicited from plants troubled by boiler blow down valve failures or repairs and from those projecting new plants.

COCHRANE CORPORATION

3144 North 17th Street, Philadelphia, Pa.

V-5





Squires Class "E" Pump Governor

The Genuine *Squires* Steam Specialties

Render efficient and lasting service. Though there have been numerous attempts at imitations in their more than 30 years existence, Squires Specialties still maintain their envious position of leadership. For full particulars of Specialties listed herein, write direct to our factory.

Squires
Trade Mark
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THE C. E. SQUIRES CO.
E. 40th St. and Kelley Ave.
CLEVELAND, OHIO
Write for Catalog E-½

Squires Boiler Feed Water Regulator

The Genuine Squires Steam Trap

Atlas Valve Co., 291 South St., Newark, N. J.
☐ Please send complete information on Atlas Float Valves. Also, please send information on the following Atlas products without obligating us in any way:—

☐ Damper Regulators	☐ Temperature Regulators	Name .....
☐ Campbell Boiler Feed	☐ Swing Joint Fittings	Firm .....
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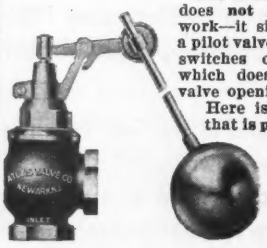
A Power Operated FLOAT VALVE



The float on this valve does **not** do the heavy work—it simply operates a pilot valve which in turn switches on the power which does the work of valve opening or closing. Here is a float valve that **is positively guaranteed.** It can be installed on the end of the line directly over or in the tank. Or, it can be installed in the supply line outside of the tank and operated by a float in the tank by means of a chain over pulleys.

The Atlas Float Valve is always smooth and positive in operation. Sizes ½ to 2 in., all bronze, 2½ to 8 in., iron body, bronze mounted or all bronze globe or angle, screwed or flanged.

Atlas makes regulating valves for every service. See list in accompanying coupon. If the list doesn't contain what you want—we very likely have it.

ATLAS VALVE COMPANY
REGULATING VALVES FOR EVERY SERVICE
291 South St., Newark, N. J.

THE DIRECT SEPARATOR CO., Inc.

has had thirty years' experience in designing Steam, Oil, Air and Special Separators; in all sizes and of various materials—cast iron, semi-steel, special alloy irons, sheet steel, riveted or welded, and special alloy steels. Please send us your separator problems.

The Direct Separator Co., Inc.
Syracuse, N. Y.

REPEAT ORDERS
Prove COPES Profitable
3,819 "repeats" from users of 10 or more COPES. Each installation has saved fuel and labor. Make similar savings in your plant. Ask us how. Write for The COPES REGISTER.
NORTHERN EQUIPMENT COMPANY
1212 Grove Drive, Erie, Pa.
COPES
SYSTEM or BOILER FEED CONTROL

Reducing the Pressure *between the Line and the* BOILER

THE Fulton Steam Reducing Valve will reduce live steam from boiler pressure, however high, to any desired pressure in the line, surely, automatically, exactly, and regardless of operating conditions. Adapted for steam heating and wherever a constant pressure below that of the boiler is required. May be used on exhaust steam at very low pressure, or as a non-return valve between boilers at different pressures. Equally efficient for controlling water or air pressures. Sizes 1 to 2½ in., in iron or best steam metal bodies, protected by a water leg. Larger sizes, weight and lever type, protected by a trap. Circular on request.

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Manufacturers of Vigilant Feed Water Regulators and Other Steam Specialties

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You take no chances

in specifying Hercules Seamless Copper Floats. More than 613,500 in service offer convincing proof of the unfailing, low-cost service they deliver. Guaranteed for working pressures up to 350 lbs. Write us about your float problems.

HERCULES FLOAT WORKS
215 Franklin St., Springfield, Mass.

HERCULES
SEAMLESS COPPER FLOATS

MONEL METAL pump rods are made in all sizes up to 3½" by 1/16" steps and are carried in stock at convenient warehouses. Write for further information — including machining instructions.

MONEL METAL PUMP RODS
"Perform Better Longer"

Monel Metal is a registered trade-mark applied to an alloy containing approximately two-thirds Nickel and one-third copper. Monel Metal is mined, smelted, refined, rolled and marketed solely by International Nickel.

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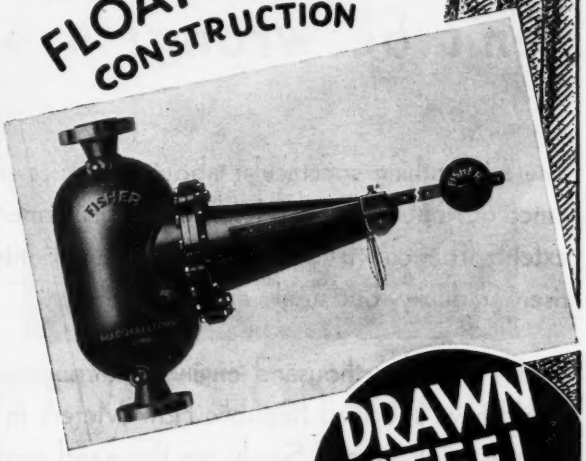
FISHER LIFTS THE CURTAIN ON AN EXTRAORDINARY ADVANCEMENT *in* FLOAT CAGE CONSTRUCTION



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Greater strength and safety, uniform wall thickness, 60% lighter in weight than cast steel, suitable for high temperature and pressures, stainless steel trimmed ball bearing stuffing box with grease seal, KA-2 stainless steel float, forged steel flanges top and bottom. Lower in price, transportation charges, and installation cost, all because of this advanced construction.

Only FISHER offers this Modern Float Cage

NEW YORK POWER SHOW BOOTH 509

Fisher Governor Company

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10,000 ENGINEERS *can't be wrong!* » » »

There is nothing spectacular about industries acceptance of Republic Flow Meters except its tremendous extent. The conviction of Republic superiority has risen gradually, but surely and substantially.

Today over ten thousand engineers throughout the world have specified Republic Flow Meters in preference to all others. Surely ten thousand engineers cannot be wrong!

Visit Booth No. 6

New York Power Show

for a complete exhibit of instruments

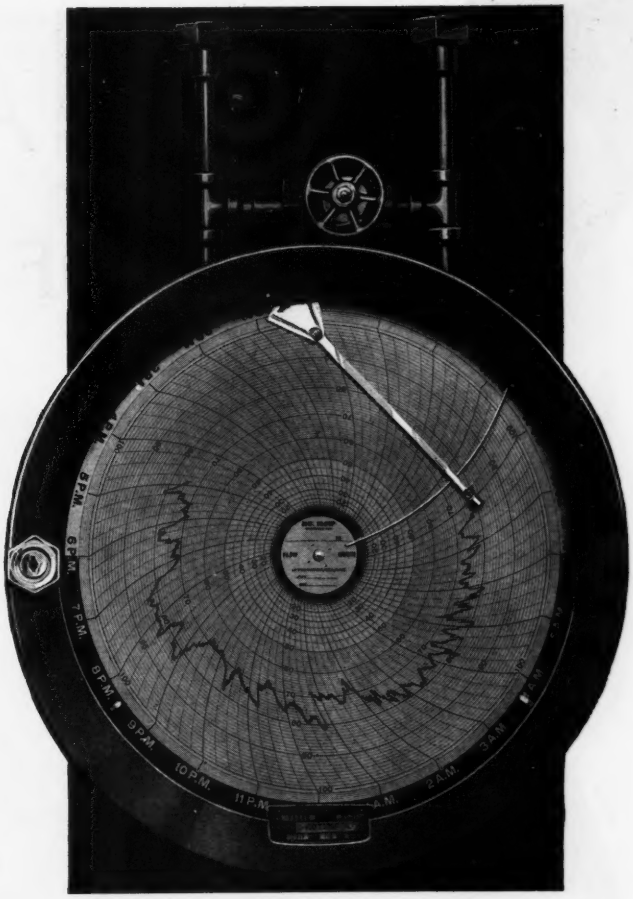
REPUBLIC FLOW METERS COMPANY

2224 Diversey Parkway, Chicago, Ill.

Over 55,000 Republic Flow Meters have been purchased by industry throughout the world

Typical Republic Flow Meter Customers

Company	Republic Meters	Repeat Orders
American Rolling Mills Co.	53	31
American Steel & Wire Co.	210	104
American Sugar Refining Co.	37	14
Associated Oil Co.	45	3
Astoria Light, Heat & Pr. Co.	51	17
A. T. & S. F. R. R. Co.	59	19
Atmospheric Nitrogen Corp.	191	44
Baldwin Locomotive Co.	32	5
Bethlehem Steel Co.	143	57
Brooklyn Union Gas Co.	173	49
Carnegie Steel Co.	352	96
Central Alloy Steel Corp.	41	19
Chevrolet Motor Co.	80	27
City of Chicago	52	15
Chicago By-Prod. Coke Co.	47	16
Chrysler Corp.	32	16
Colorado Fuel & Iron Co.	34	10
Columbia Steel Co.	50	16
Container Corp. of America	56	17
Corn Products Refining Co.	121	38
Crown Willamette Paper Co.	37	15
Cudahy Packing Co.	36	10
Deere & Company	37	14
Detroit City Gas Co.	64	24
Dow Chemical Co.	48	20
E. I. DuPont de Nemours & Co.	217	68
Eastman Kodak Co.	40	30
Firestone Tire & Rubber Co.	46	21
General Aniline Works	102	38
Goodyear Tire & Rubber Co.	96	22
Great Southern Lumber Co.	37	6
H. J. Heinz Co.	43	10
Hercules Powder Co.	58	18
Illinois Maintenance Co.	43	6
Illinois Steel Co.	92	46
International Paper Co.	65	15
Johns-Manville, Inc.	74	25
Jones & Laughlin Steel Co.	36	20
Mathieson Alkali Works	52	19
Minnesota & Ontario Paper Co.	75	12
Missouri-Kansas-Texas R. R.	36	7
Morton Salt Co.	53	6
Fiberboard Products Co.	61	12
National Tube Co.	60	26
New Orleans Public Service Co.	30	3
Penick & Ford	38	10
Peoples Gas Light & Coke Co.	107	41
Procter & Gamble Co.	35	13
Quaker Oats Co.	48	17
Republic Iron & Steel Co.	37	12
St. Lawrence Paper Mills	57	10
Shell Petroleum Corp.	218	90
A. E. Staley Mfg. Co.	53	20
Standard Oil Co.	372	110
Standard Steel Car Co.	38	15
Swift & Co.	127	69
Tennessee Coal, Iron & R. R.	134	70
U. S. Government	121	72
Vacuum Oil Co.	60	26
West Pennsylvania Power Co.	48	5
West Virginia Pulp & Paper Co.	188	78
Western Electric Co.	41	23
Wheeling Steel Corp.	89	36
Wisconsin Steel Works	46	20
Youngstown Sheet & Tube Co.	216	81



NOW

You Can Measure Flow ACCURATELY Under Varying PRESSURE or TEMPERATURE CONDITIONS

The Brown Mechanical Flow Meter can be equipped with automatic compensation for static pressure or temperature, and may also, if desired, have pens to record the static pressure or temperature.

Assuming a constant rate of flow under varying pressures, the manometer float will move to different positions as the density of the fluid varies with pressure, and the pressure actuates the Bourdon helix which adjusts a sensitivity link to corresponding positions so the pen will continue to indicate the same constant rate of flow.

Automatic compensation in the Brown Mechanical Flow Meter is exceedingly simple and affords the frequently desired compensation for static pressure or temperature.

Write for Catalog 2201

THE BROWN INSTRUMENT COMPANY
4491 Wayne Avenue Philadelphia, Pa.
Branches in 22 principal cities

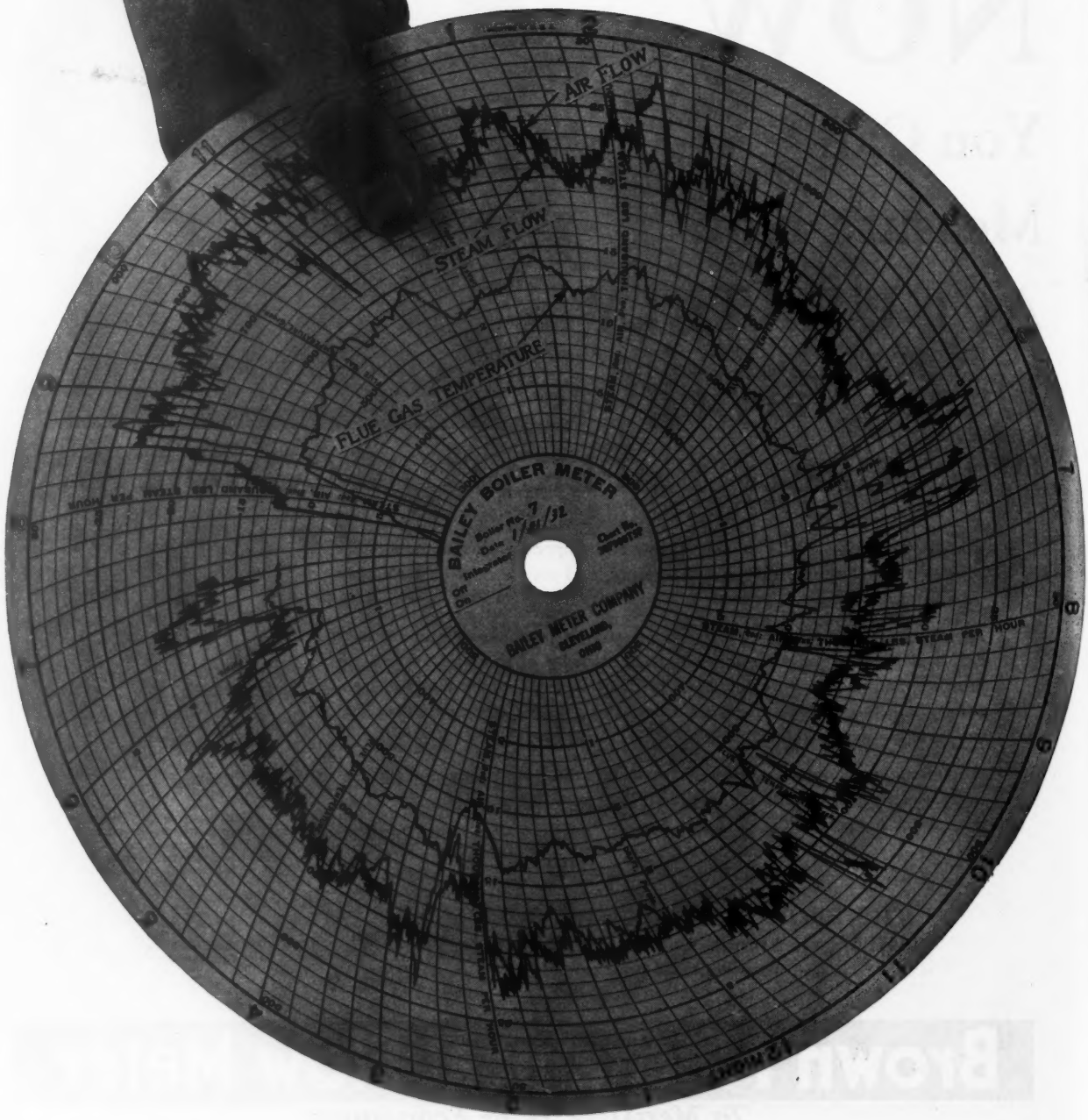
If there is an application in your plant for Flow Meters consult our engineers. At least, send for full information about the new Brown Mechanical Flow Meter. Ask for Catalog No. 2201.

See this flow meter in operation at Booth No. 48 at The New York Power Show, Dec. 5th to 10th, 1932.

Brown Mechanical Flow Meter

To Measure is to Economize

A HANDFUL OF FACTS...



Two of the seven Bailey Boiler Meters referred to below

*leads another manufacturer**

TO INCREASED PROFITS

Merely a chart from a Bailey Boiler Meter . . . but daily charts like this have led another industrial plant to increased profits. By guiding operation of seven 400 h.p. stoker fired boilers with Bailey Boiler Meters, a large eastern soap manufacturer is saving approximately $100.00 weekly in fuel costs alone. The initial investment was returned in a few months and the equipment continues to pay ample dividends week after week.

Each Bailey Boiler Meter presents to the operator in a logical manner the handful of facts essential to economical boiler operation. It totalizes and records Steam Flow from the boiler, records Air Flow supplied for combustion, and records Flue Gas Temperature. Observation of this data enables the operator to continuously maintain the correct air supply and to clean tubes or repair baffles at the proper time. Let us show you how Bailey Boiler Meters can increase your margin of profit. Write for Bulletin No. 44.

★ Name on request.

Boiler Meters
Combustion Control
Multi-Pointer Gages
Feed Water Control
Fluid Meters
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See our Exhibit in Booths No. 50, 51, 54 and 55 at the New York Power Show.

D-15

BAILEY METER CO.

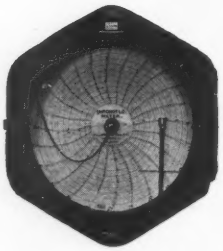
1040 IVANHOE ROAD CLEVELAND, OHIO.

Bailey Meter Company Limited, Montreal, Canada

UNIQUE DEMONSTRATION

at the

New York Power Show



Flow Metering from Distant Points
Over Regular Telephone Circuits

by

CHRONOFLO

The new, powerful electric flow meter that's different

Booth No. 28

BUILDERS IRON FOUNDRY
PROVIDENCE, R. I.

Divide the Water by the Coal the dependable SIMPLEX METER Way

Wide Range
Rugged
Sensitive
Accurate
Dependable

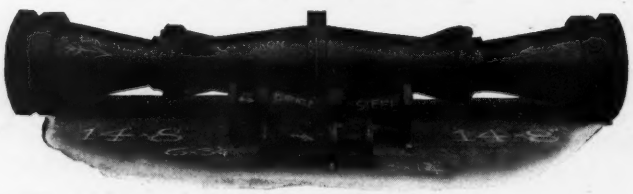
This is the way in which scores of leading plants determine the boiler evaporation rate and help hold down operating costs.

Simplex Boiler Feed Meters are of the Venturi-type. Although simple and rugged in construction they are fast and sensitive, read accurately over a wide range of flow.

Simplex Meters are also widely used for measuring the rate of flow of turbine condensate, make-up or water used for other purposes. Write today for descriptive Bulletins 32-A and 42.

Simplex Valve & Meter Co.

6751 Upland St., Philadelphia, Pa.



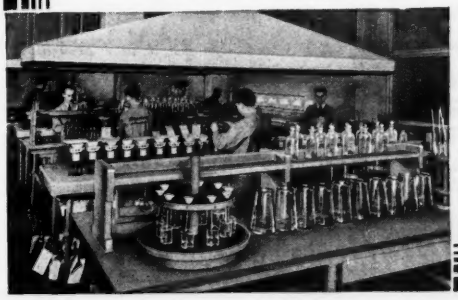
Simplex Venturi Tubes

Confine Experiments to the Laboratory and Use Proven Methods Only for Your Boilers

Dearborn

Water Treatment Service Represents:

A complete survey of your plant and operating conditions.
Data prepared following analysis in the Dearborn Laboratories as to the mineral content of the boiler water supply.
Specific Treatment recommendations to correct harmful tendencies.
Services of Chemical Engineering Department always available.
Responsible assurance of satisfactory and economical results.
The Dearborn method embraces at all times the most up to date developments and information in the boiler feed water treatment field.
Dearborn Service is complete in preventing scale formation, foaming, pitting, corrosion and embrittlement.



Additional Dearborn Services to Power Plants

Water Testing Cabinet makes all the tests required for efficient boiler operation.
New Improved Concentration Hydrometer—All readings on a single float.
Dearborn Treating Plants—Proportioning equipment suited to any service.
Cleaning Scaled Equipment—Rapid, inexpensive, thorough.
Water System Protection—Prevents corrosion and scale.
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NO-OX-ID—"The Original Rust Preventive." Used alone or as a base for paint over steel.
Scientific Lubricants
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Combustion Control
Steam Purifiers *Steam Separators*
Boiler Water Conditioning
(for the prevention of scale and corrosion)

HAGAN CORPORATION
Combustion and Chemical Engineers
BOWMAN BUILDING, PITTSBURGH, PENN.

Lonergan

Chime Whistle—Model "WV"
Bells of solid cast bronze. Adjustable lever. A worthy member of "The Lonergan Line" of safety valves, relief valves, pressure and vacuum gauges, oil and water gauges, lubricating devices, etc. Famous since 1872.
Write for Catalogue of "The Lonergan Line"
J. E. LONERGAN CO.
217 RACE STREET » PHILADELPHIA, PA.

300 specialties for power plants

BROOKS IMPROVED BOILER METAL TREATMENT

Not a Water Treatment—
Not necessary to analyze the water when using Brooks—water is ever changing in its composition and cannot be successfully treated by stock compounds. Brooks works successfully under all water conditions.

Does Not Work Chemically—
but mechanically, by expansion under heat.

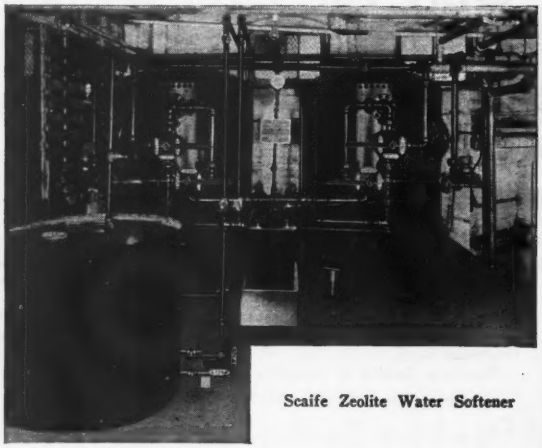
Removes Old Scale—
and prevents new from forming after old scale is removed.

Prevents Rusting, Pitting, Corrosion
Write today for New Booklet
Just Prepared outlining trial offer

THE BROOKS OIL CO., Cleveland, Ohio

GUARANTEED BY BROOKS OIL CO.

Water Softeners and Filters for every Industrial and Domestic Use



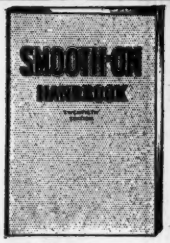
Scaife Zeolite Water Softener

Cold Process: Intermittent, Continuous and Zeolite. Hot Process, Semi-Hot Process and specially designed Water Softeners.
Gravity, Pressure and Oil Removal Filters.
Write for Information and Bulletins.

WM. B. SCAIFE & SONS CO.
OAKMONT, PA.
NEW YORK PITTSBURGH CHICAGO

TAKE THE GRIEF OUT OF EMERGENCY REPAIRS

HUNDREDS of emergency repairs and many routine maintenance jobs can be handled quickly, easily and cheaply with Smooth-On No. 1, which seals joints, cracks and breaks and holds equally well in any metal.
Smooth-On No. 1 expands in hardening and when metallized becomes as dependable as the metal which surrounds it. Engineers and shop men prefer the Smooth-On method because of the simple cold application and the speed with which a reliable and permanent repair is assured.



Write for this FREE BOOKLET

The directions and diagrams in the Smooth-On Handbook will post you well on Smooth-On, where to use each kind, how to apply for best results, and what to expect from the finished job, based upon pictures and data from typical applications.

Get Smooth-On No. 1 in 1 or 5-lb. can or 25 or 100-lb. keg from any hardware store or from us.

SMOOTH-ON MFG. CO., Dept. 31
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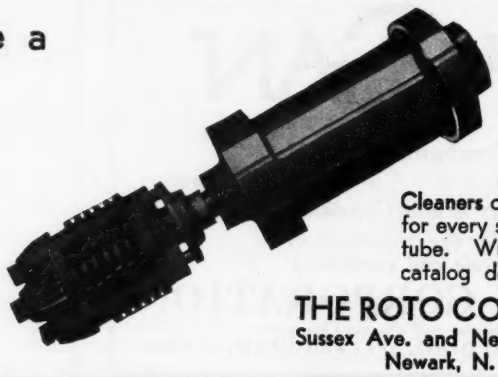
Do it with SMOOTH-ON

Get Cheaper Steam—Use a ROTO TUBE CLEANER

Frequent tube cleaning with a ROTO will help your boilers, economizers and heaters do better work and produce steam at notably lower cost. . . . . You'll find a ROTO does the job quickly and thoroughly —requires much less cleaning time. . . .



ROTO Tube Cleaners can be furnished for every size and type of tube. Write today for catalog describing them.

THE ROTO COMPANY
Sussex Ave. and Newark Street
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Feedwater

softened with Greensand Zeolite is free from ALL scale-forming ingredients. The Zeolite Process is simple, easy to operate, and dependable in every way. A pamphlet on *Scientific Feedwater Conditioning* will be sent on request.

ZEOLITE GREENSAND ZEOLITE

Zeolite Chemical Co., 90 West St., New York

STOP FUEL LOSSES

WITH A

Dean
REG. U.S. PAT. OFF.

Boiler Tube CLEANER
(For all types of boilers)

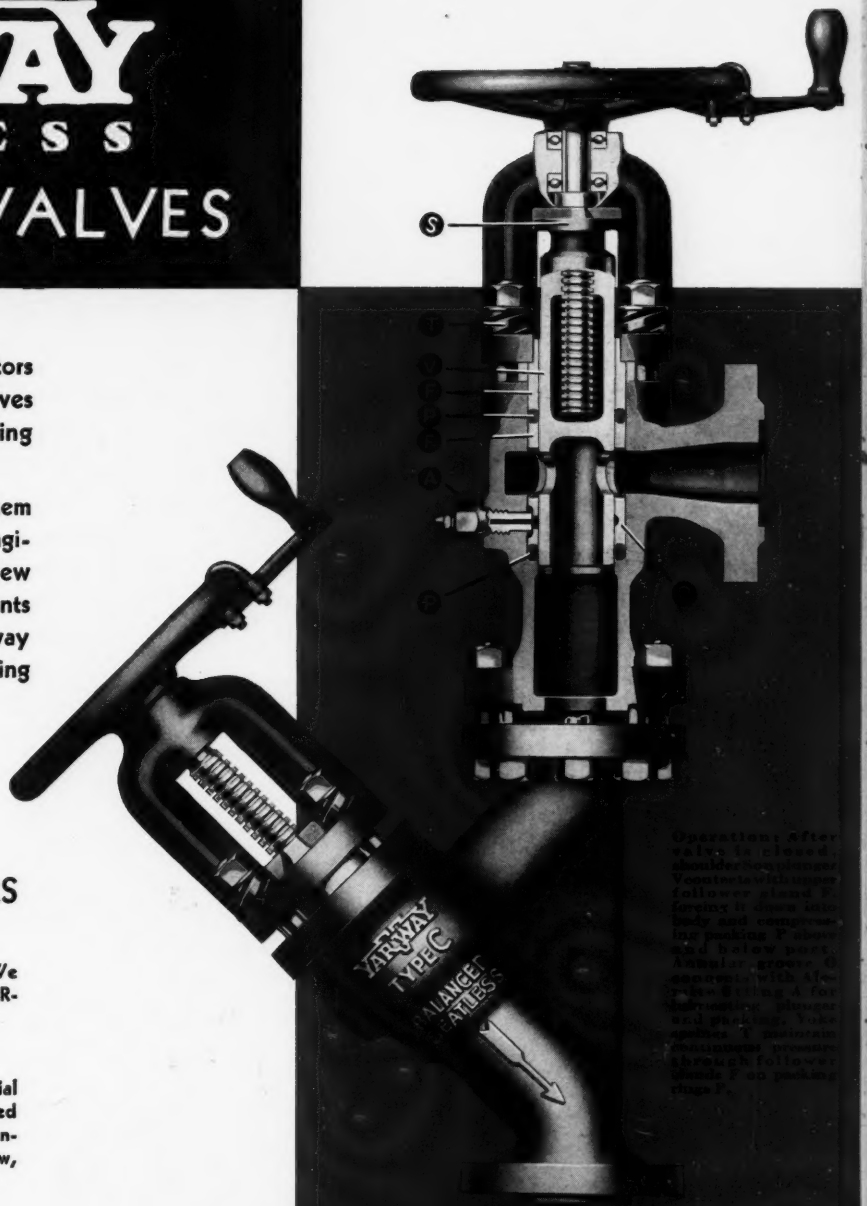
The Dean Cleaner is *guaranteed* to save you money. It is offered on trial for any type of boiler. Write for data and catalog today.

THE WM. B. PIERCE CO.
149 Ellicott St. Buffalo, N. Y.

YARWAY
SEATLESS
BLOW-OFF VALVES

Since June 1st, Hundreds of Plant Operators Have Brought Their Yarway Blow-Off Valves Up-to-the-Minute with These Outstanding Recent Improvements.

Whatever the Age of Your Valves, Make Them Last Years Longer. Take Advantage of Engineering Progress That Offers an Entirely New Conception of Valve Service — Improvements That Can Not Only Be Obtained in New Yarway Valves, But Can Also Be Built Into Existing Equipment. Write. Ask. Act Today.



Slip in a New Nitralloy Plunge
FOR TWO YEARS — in any

HERE ARE THE IMPROVEMENTS YARWAY OFFERS

●

NITRALLOY PLUNGERS (guaranteed for two years). We also supply plungers of AMBRAC, STAINLESS STEEL, EVERBRITE to meet special conditions.

●

IMPROVED PACKING — Manufacture, according to special formula, controlled by Yarway. Compressed and heat treated for the specific pressures and temperatures to be encountered. Plain and armored types. Made in three grades for low, medium and high pressures.

●

YOKE SPRINGS maintain continuous pressure on packing train at all times, keeping valve tight and protecting packing. Yoke springs and longer studs to accommodate springs may be easily applied to any Yarway Valves in the field.

●

ALEMITE LUBRICATION for plunger and thrust bearings in yoke. Improves ease of operation, preserves packing, and lengthens life of valve. Easily applied to existing valves if returned to our shop.

●

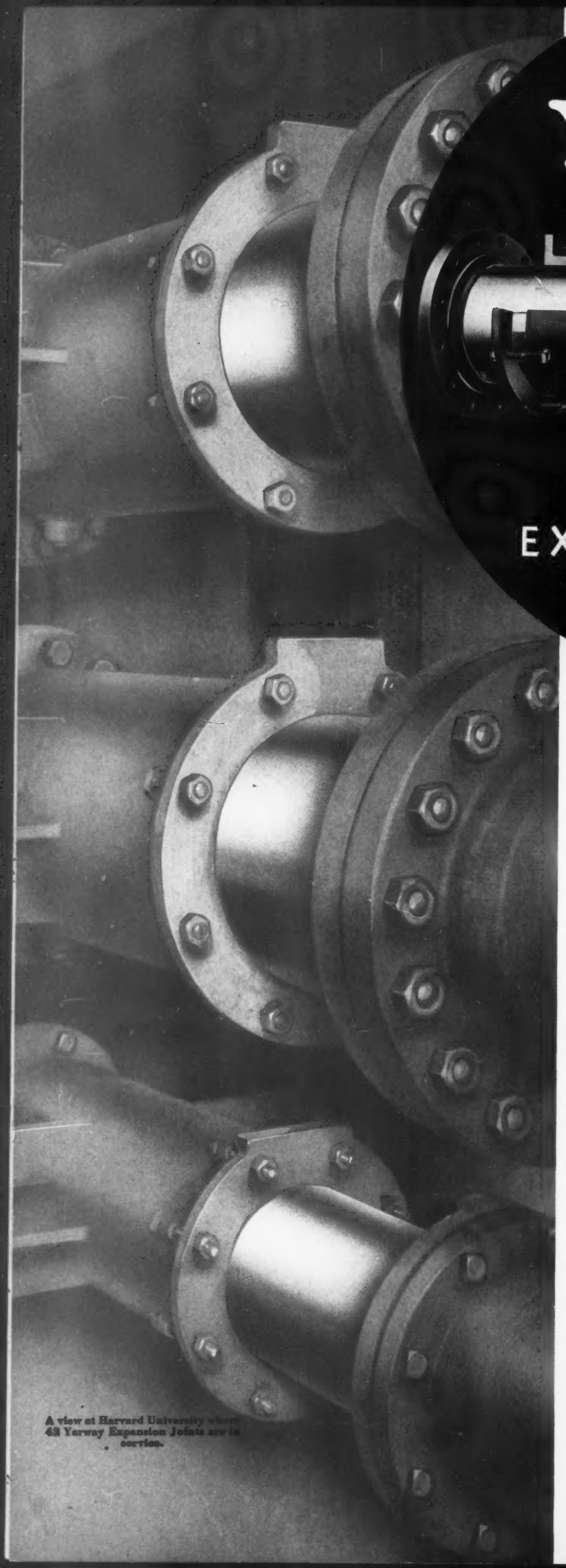
GREASE DISTRIBUTING GLAND. Special lower follower gland for use with Alemite lubricated valves. An annular groove in the gland receives grease from the fitting and distributes it evenly around the plunger.

●

OPERATING HANDLE of new construction can be attached to any Yarway handwheel. Makes blowing down easier and insures that valves are closed down tight.

●

YARNALL-WARING COMPANY
Mermaid Street, Philadelphia



A view at Harvard University where 42 Yarway Expansion Joints are in service.

YARWAY

CYLINDER GUIDED EXPANSION JOINT

SEVEN REASONS FOR YARWAY POPULARITY

1. Welded wrought steel to match the steel pipe lines in which they are used.
2. Cylinder-guided sliding sleeve, made of heavy chromium-covered wrought steel or of centrifugally cast bronze, resists corrosion and erosion.
3. Cylinder guide, surrounded by hot liquid or steam at all times, expands equally with the sleeves, securing extremely close clearance with freedom of movement.
4. Sliding sleeve away from inside bottom of body dirt pocket, prevents rust, scale, sand, etc., from cutting sleeve.
5. Alemite lubrication of sliding sleeve and cylinder guide.
6. Easily accessible packing gland for adjustment and re-packing. Large, deep stuffing box.
7. Smaller diameter than pipe flange—no large tunnel space required.

The trend is toward steel—toward Yarway Welded Steel Expansion Joints for safety, permanence, convenience, real savings in installation and maintenance costs.

YARNALL-WARING COMPANY

Mermaid Street Philadelphia

SINGLE TYPE—WITH BASE

They're both CHEMICAL ENGINEERS

One is a specialist in steel production . . . . The other controls the processing of rubber

TWO processes—such as the making of steel and rubber—may both require able chemical engineers and still have so little in common that neither man could handle the other's job satisfactorily.

Water treatment is just as much a specialized field of chemical engineering as is the control of one of these manufacturing processes. The problems involved are so important and so varied that their solutions can only be entrusted to qualified water treating engineers.

One of the biggest assets of this company is its staff of such engineers. Their work in analyzing boiler water conditions and suggesting the proper remedy for ailing steam plants is fully as important to our customers as the K.W.S. Sodium Aluminate which we may furnish.

The K.W.S. system is the combination of the best sodium aluminate which can be produced and an engineering service by men who *know* that one special field and devote their entire attention to it. This system has demonstrated its money-saving value in thousands of plants of leading companies in all industries and in all parts of the country. You cannot take a chance when you join this large group of users because we will not install the K.W.S. System in any plant where our survey does not show an opportunity for positive improvement in conditions.

You assume no obligation whatever in using the coupon.

NATIONAL ALUMINATE CORPORATION
6224 W. 66th Place, Chicago, Ill.

THERE ARE MANY VARIETIES OF ENGINEERING— WE KNOW ONE

National Aluminate Corporation
6224 W. 66th Place, Clearing Sta., Chicago, Ill.

Send me your free booklet, "Standardized Feedwater Treatment".

Have an engineer make a feedwater survey of my plant. This does not obligate me in any way.

Give me names of nearby users of K.W.S. or companies with plants similar to mine.

Name.....
Title.....
Company.....
Address.....
Type of Plant.....
City.....State.....

K.W.S. SODIUM ALUMINATE SYSTEM

PPE—12-Gray

New! FULLY Soft Water at *lower* Cost

AS its contribution to the more efficient production of steam, The Permutit Company has developed for the needs of 1933 a fully automatic zeolite water softener which, by increased efficiency, is able to produce zero hardness water at lower cost than ever before. This new softener is completely self-regenerating and requires merely the occasional loading of salt into the salt storage tank.

The operation is controlled by a water meter, time switch and float switch. This fully automatic operation has been made possible by the development of Permutit's single valve control. The valve, motor-operated—is the heart of the system.

This automatic water softener possesses many advantages, the major ones of which are tabulated (extreme right) for your convenience. Note particularly that a plant can be equipped with fully automatic water softening equipment at no greater cost than for the manually operated kind. Adaptable to Present Equipment. These automatic features, (which are exclusively Permutit's), can be applied to any existing downflow zeolite water softener.

* * *

A demonstrating model of this new equipment will be shown for the first time at the Power Show in New York on December 5th to 10th, 1932. Come to Booth 348, see for yourself how it operates.

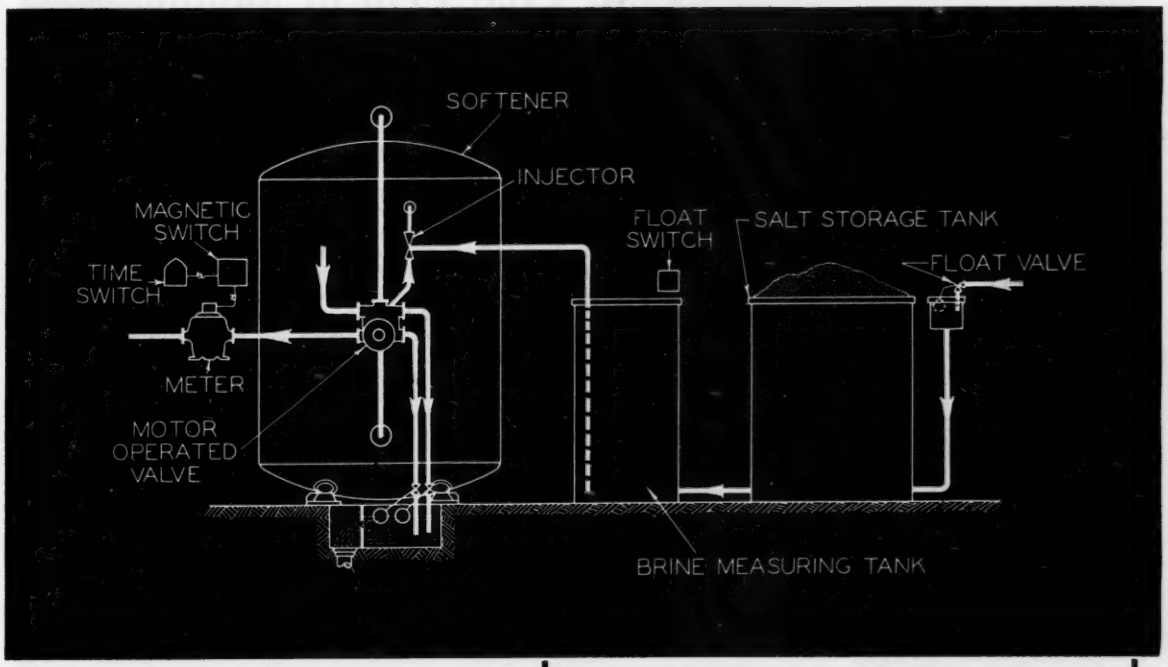
Full particulars in reference to your plant gladly supplied—just write "Tell me about your new Automatic." The Permutit Company, 440 Fourth Avenue, New York City.

How It Operates

Referring to the schematic diagram, the first step in the regeneration is initiated by the meter, after a specified number of gallons of water has passed through it. Electrical contacts in the meter head actuate the valve motor, which rotates the valve to backwash position, reversing the flow of water through the zeolite bed from its normal downward course. The upward flow of water cleanses the zeolite and flushes off to the sewer impurities which have been retained on the surface of the bed.

This operation continues for a specified number of minutes and is then brought to a conclusion by the time switch. The valve rotates to its next position, brining.

AUTOMATIC.!



In the brine measuring tank, the exact amount of saturated salt solution for one regeneration is available. Through the action of a hydraulic injector, this tankful of brine is quickly sucked into the top of the softener. A float switch at the brine measuring tank operates when the level falls, and shuts off further brine flow, by causing the valve motor again to turn the valve.

Thus the final operation—the rinse—is started, where the brine is washed through the zeolite. During this operation, the time switch is in control, and after the passage of a predetermined interval of time, actuates the valve motor, shuts off the rinse and brings the single valve back to its original softening position. During this complete cycle, the valve turns through 360°.

NINE ADVANTAGES

1. **Most efficient zeolite water softener ever built.**
2. **All operations automatically carried out under precise control.**
3. **Completely softened water—no overrunning, no under-regeneration.**
4. **Thorough washing assures clean, active zeolite.**
5. **Saves salt—uses only the absolute minimum required.**
6. **Is completely and thoroughly rinsed with minimum quantity of water.**
7. **Less floor space—more salt storage.**
8. **Prices comparable with manually operated equipment.**
9. **Automatic features can be applied to any existing downflow zeolite water softener.**

Permutit

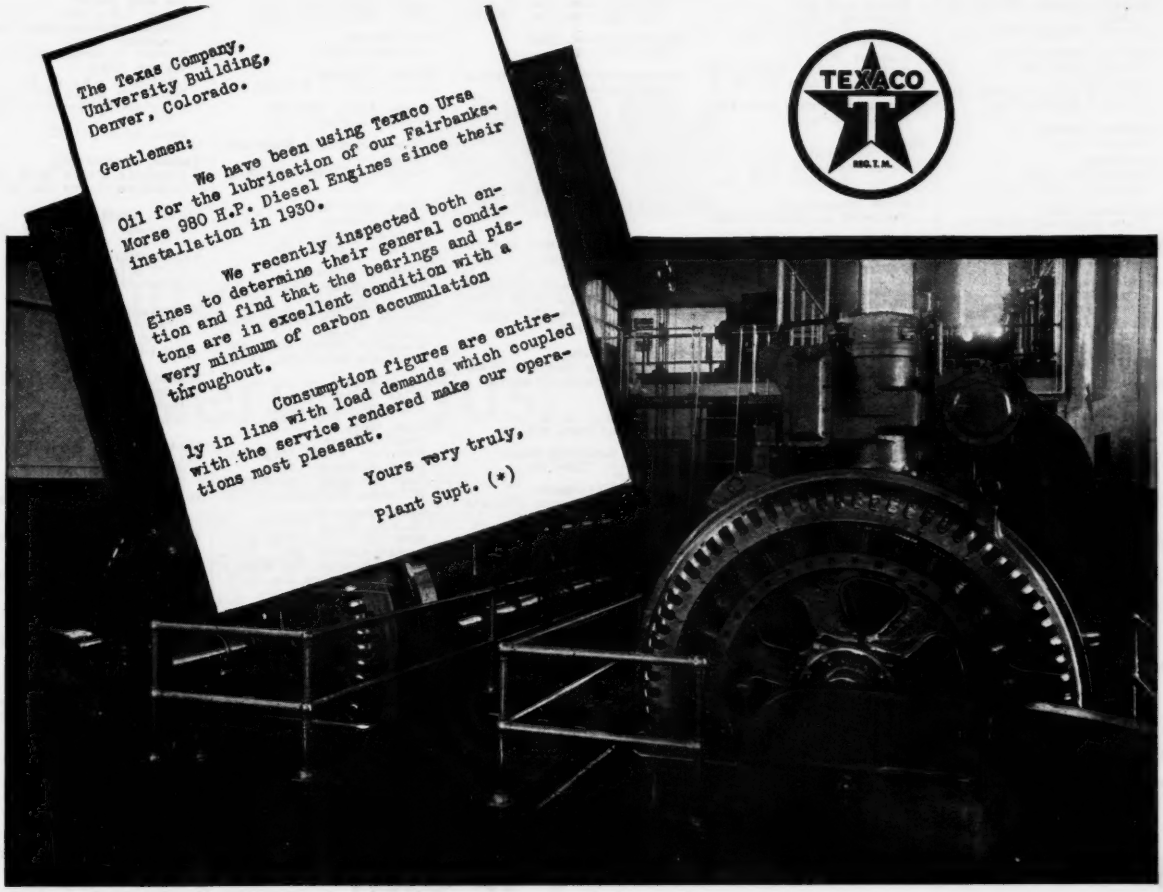
Water Treating Equipment

Your Firm Will Approve Spending a Little Money to Save a Lot of Money

Engineers in a number of plants, where five to ten tons or more of ashes are removed daily, have saved their firms thousands of dollars annually, by the installation of the Hydrojet System of Ash Removal or Hydroseal Ash Pumps. In one plant alone, an expenditure of about $3000 saved $10,000 yearly. Wherever ash handling is a dirty task, it is usually expensive too, either in maintenance or operation or both. If you would go to your firm with plans and figures proving that a small investment in Hydrojet or Hydroseal Methods would be saved in a short time, both you and your firm would benefit. Our engineers will gladly work with you in adapting our systems to meet your conditions and in estimating what savings will result. No matter how you handle ashes, we can refer you to a plant where Hydrojet Methods have saved money under similar conditions. The illustrations show an installation in a plant that formerly dumped ashes into lorry cars. The Allen-Sherman-Hoff Co., 229 S. 15th St., Philadelphia. Offices in Principal Cities.

HYDRO JET

Nothing Moves but the Ashes


The Texas Company,
University Building,
Denver, Colorado.
Gentlemen:
We have been using Texaco Ursa Oil for the lubrication of our Fairbanks-Morse 980 H.P. Diesel Engines since their installation in 1930.
We recently inspected both engines to determine their general condition and find that the bearings and pistons are in excellent condition with a very minimum of carbon accumulation throughout.
Consumption figures are entirely in line with load demands which coupled with the service rendered make our operations most pleasant.
Yours very truly,
Plant Supt. (*)
TEXACO
REG. U.S. PAT. OFF.

(*) Name on request

LACK OF CARBON ACCUMULATIONS IS "PHENOMENAL"

Here's another clean record for Texaco Ursa Oil. These two 980 h.p. Fairbanks-Morse Diesel engines have been in service *nearly three years* with Texaco Ursa Oil as the lubricant. When inspected, they were found in perfect condition with no evidence of wear and a freedom from carbon deposits that was phenomenal considering the variable load demands of the plant.

The Plant Superintendent is particularly enthusiastic. Read his letter. At this plant, as in hundreds of others, Texaco Ursa Oils and Texaco lubrication engineering service are giving an unusual degree of satisfaction in better engine performance through more effective lubrication. Write The Texas Company to show you what is being accomplished in Diesel lubrication.

THE TEXAS COMPANY, 135 East 42nd Street, New York City

TEXACO LUBRICANTS

Pumps, Waterworks
Moore Steam Turbine Corp.
Warren Steam Pump Co.

Purifiers, Boiler Feed
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Regulators, Damper
Atlas Valve Co.
Brown Inst. Co., The.
Hagan Corp.
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Sarco Co., Inc.

Regulator, Fan Engine
Atlas Valve Co.

Regulators, Feed Water
Atlas Valve Co.
Bailey Meter Co.
Chaplin-Fulton Mfg. Co.
Northern Equipment Co.
Ruggles - Klingemann Mfg. Co.
Sarco Co., Inc.
Squires Co., C. E.

Regulators, Pressure
Chaplin-Fulton Mfg. Co.
Fisher Governor Co.
Hagan Corp.
Northern Equipment Co.
Ruggles - Klingemann Mfg. Co.
Sarco Co., Inc.
Squires Co., C. E.

Regulators, Temperature
Atlas Valve Co.
Brown Inst. Co., The.
Ruggles - Klingemann Mfg. Co.
Sarco Co., Inc.

Rust Preventives
Dearborn Chem. Co.

Scale Removers (Mechanical)
Pierce Co., Wm. B.
Roto Co., The.

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Hagan Corp.
Hoppes Mfg. Co.
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Williams Valve Co., D. T.

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Hagan Corp.

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National Tube Co.

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Allen Sherman Hoff Co.

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Valves, Globe
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Kennedy Valve Mfg. Co.
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Vogt Machine Co., Henry
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Kennedy Valve Mfg. Co.
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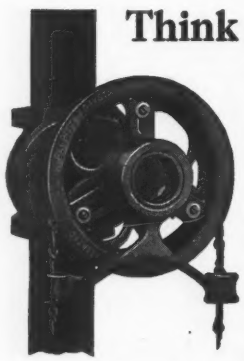

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with Babbitt Sprocket Rims on all your "high-up" valves. No need of keeping a long, cumbersome ladder always on hand just to close a valve.

Babbitt Rims give you instant and positive control of overhead valves from the floor—save time, steam and accidents. Adjustable to any valve, easily attached and low in cost. Don't delay. Get your Babbitt Rims now! Complete information on request.

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—Adjustable—
SPROCKET RIM
with Chain Guide

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ATTEND THE NEW YORK POWER SHOW
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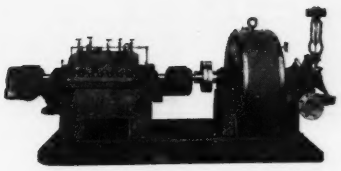
At this season of the year many subscribers change their place of residence. If the Post Office is notified of the change they will forward first class mail to the new address but **they will not forward magazines.** It is important that you notify us as well as the Post Office, giving us both your old and new addresses, so that there will be no delay in receiving your copies of POWER PLANT ENGINEERING at your new address. We are very anxious to give prompt service and will appreciate your sending us notice before you move, if possible.

POWER PLANT ENGINEERING
53 W. Jackson Blvd. Chicago, Illinois



Pumping ECONOMICALLY versus Just PUMPING

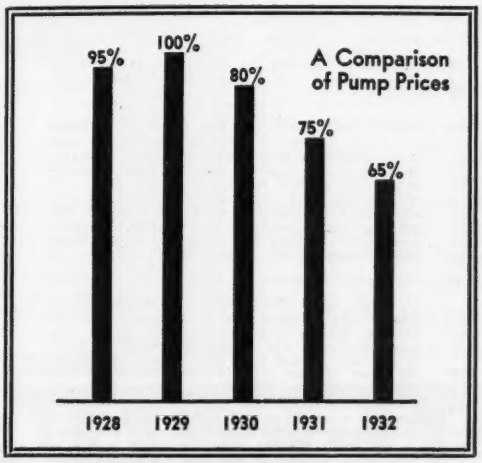
Possibly it was fun for a while, but honestly now, aren't you weary of nursing along those creaky, slipping, steam-wasting old water pumps? Aren't you longing for new, smooth-working pumps that do their jobs economically?

Pump prices today are approximately 35 per cent lower than they were in 1929. Now that the pendulum of business is swinging upward prices are almost certain to advance. Today's outstanding bargains in pumps and other power machinery and equipment will be tomorrow's memories.

The notably improved production economies effected through the installation of modern pumps — together with modern boilers, stokers, heat insulations, turbo-generators, fans, feedwater heaters, etc.—will improve your company's ability to meet competition and strengthen your earning power.

Another reason for replacing inefficient, run-down-at-the-heels power plant machinery and equipment now is that changes can be made most easily when plants are not too busy. Then, too, financial and credit situations are clearly better.

Take advantage of today's bargain prices and make those normal replacements and improvements which have been neglected in the last three years. To economize now, modernize now. Let today's savings in generating and utilizing heat, light and power assure tomorrow's profits.



Today's pump prices are approximately 35% below those of 1929. Other power plant machinery and equipment may be installed at equally attractive savings. Now is the time to modernize your plant and strengthen your profit-earning ability.

SIGNBOARD SECTION

Quick Action Opportunities

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A.C. UNITS
3 ph.-60 cy.-2300/440/220 volts.

600 KW. G.E.—30x42 Hamilton corliss engine ..... $3500.
187 KVA. G-E.—Skinner uniflow engine ..... 2250.
240 KVA. G.E.—Harrisburg uniflow engine ..... 2250.
312 KVA. Al. Chal.—Erie Ball 4 V. engine ..... 2750.
625 KVA. Westinghouse Turbine Unit, extraction type ..... 3250.
400 HP. Springfield WT. BOILER, 225 lb., ASME code..... 2750.

POWER PLANT EQUIPMENT CO., INC.
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AIR COMPRESSORS
BOUGHT—SOLD—EXCHANGED
All types and sizes.
Send us your inquiries.
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Earl E. Knox Company, Erie, Pa.
25 years experience in engineering, installation and application of compressors.

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3 PHASE, 60 CYCLE, 2300 VOLTS
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Installed new August, 1927.
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Both the above outfits are in excellent condition throughout; still on original foundation.
Write or Wire for Details and Prices.
The National Power Machinery Co.
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4—Water Tube Boilers, 250 HP each, ASME, 165 lbs. allowed for reset. Complete fittings, settings, & piping. Can ship without cutting tubes. Stokers available if desired. Will sell singly or in pairs. Extremely low price.
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PLANT OR CHIEF ENGINEER available for industrial or utility plant. 16 years experience in erection, operation and maintenance of all kinds of generation equipment. Holds Chicago City License. Special knowledge of refrigeration equipment. Age 39, married. Long training with one of the largest equipment companies in the country. Prefers location in northern Illinois or Wisconsin but willing to go anywhere. Write to Box 1160, c/o Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

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6¾ Plain Envelopes	$2.95
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Send sample for Estimate.
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DAVID NICHOLS CO.
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POWER PLANT POSITION WANTED. Any job as a start to prove ability, Plant Engineer, Second Engineer to caretaker. 15 years experience includes operation and maintenance of boilers, engines, pumps, elevators, motors, refrigeration and other machinery. Hold First Class Ohio License and can give excellent references. Can go anywhere. Please write to Box 1164, c/o POWER PLANT ENGINEERING, 53 W. Jackson Blvd., Chicago.

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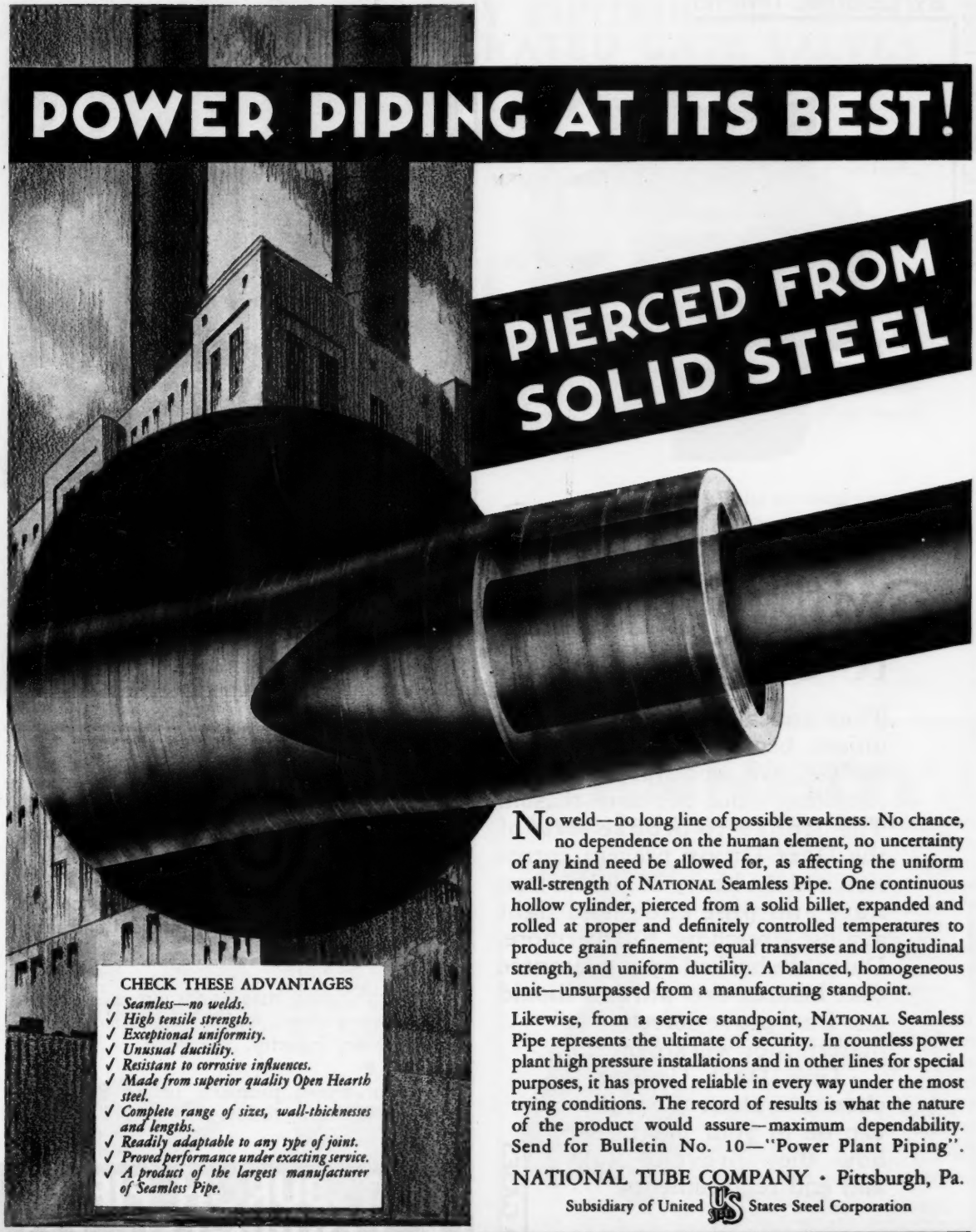
POWER PIPING AT ITS BEST!

PIERCED FROM SOLID STEEL



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- ✓ *Seamless—no welds.*
- ✓ *High tensile strength.*
- ✓ *Exceptional uniformity.*
- ✓ *Unusual ductility.*
- ✓ *Resistant to corrosive influences.*
- ✓ *Made from superior quality Open Hearth steel.*
- ✓ *Complete range of sizes, wall-thicknesses and lengths.*
- ✓ *Readily adaptable to any type of joint.*
- ✓ *Proved performance under exacting service.*
- ✓ *A product of the largest manufacturer of Seamless Pipe.*

No weld—no long line of possible weakness. No chance, no dependence on the human element, no uncertainty of any kind need be allowed for, as affecting the uniform wall-strength of NATIONAL Seamless Pipe. One continuous hollow cylinder, pierced from a solid billet, expanded and rolled at proper and definitely controlled temperatures to produce grain refinement; equal transverse and longitudinal strength, and uniform ductility. A balanced, homogeneous unit—unsurpassed from a manufacturing standpoint.

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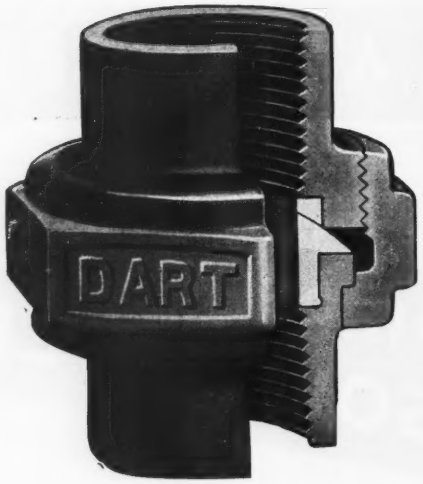
NATIONAL TUBE COMPANY · Pittsburgh, Pa.

Subsidiary of United States Steel Corporation

NATIONAL SEAMLESS

PIERCED FROM SOLID BILLETS - NO WELDS

SAVE THE MONEY LOST BY LEAKING UNIONS



Use DARTS with the bronze-to-bronze seats

They are called "double service" unions because they commonly outlast two ordinary unions. And that's not the only reason. The bronze-to bronze seats of the Dart Union prevent corrosion and the heavy malleable iron nuts and pipe ends hold tight against stretching. Furthermore, Darts are backed by a guarantee that insures two unions should one Dart prove defective in materials or workmanship. . . Give Dart Unions a chance to show what they can do in your plant. See how they prevent leaks and end replacements.

E. M. Dart Manufacturing Co.
Providence, R. I.

Sales Agent: The Fairbanks Company, New York, and at all branches

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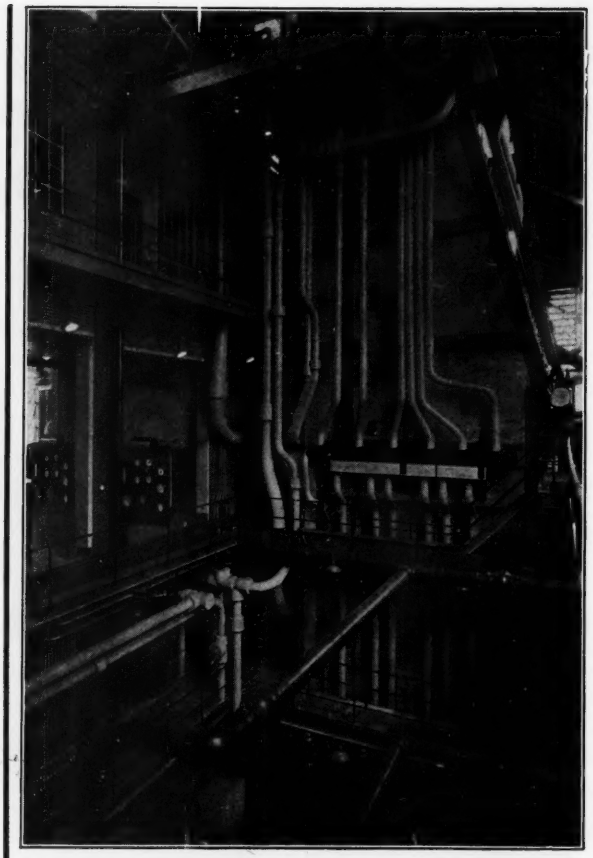
FOR STEAM, WATER AND OTHER FLUIDS AND GASES



Side wall view of boiler installation at Bremo Bluff, designed and constructed by the Electric Management & Engineering Corp., New York, New York.

The complete piping system at Bremo Bluff was fabricated and installed by Pittsburgh Piping and Equipment Company.

It is a typical example of our experience and ability to construct a highly efficient and satisfactory piping job.

Pittsburgh Piping installations include high and low pressure steam, water, oil and air in practically every industry.

Put your piping problems up to Pittsburgh Piping. Write us today.

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1. Bring your most distant and inaccessible Gate Valves to your finger tips.

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2. Operate all of your Gate Valves from one central Control Board.

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3. Control may be at either one or several locations.

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4. Particularly adapted for automatic control from pressure switch, temperature switch, float switch, photo-electric cell, loss of electrical energy, etc.

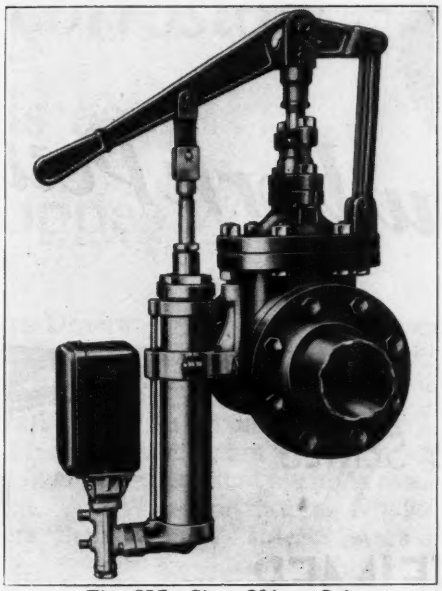

Fig. 215. Sizes 2½ to 8 in.

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5. Can be used on water lines as Stop Valves, without air chambers, as operation is very moderate and will not affect water hammer.

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Write us about your requirements.

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Use VULCODISC

for trouble-free valve jobs

In renewing the disc, note how easily and quickly the Vulcodisc Jiffy Disc Holder slips off the stem head. Only the disc lock nut to remove and the old disc is off and replaced in a jiffy.

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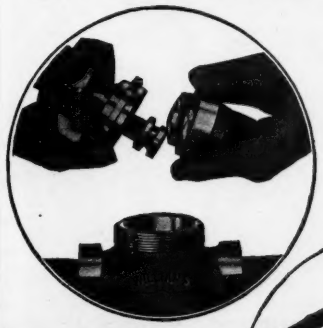
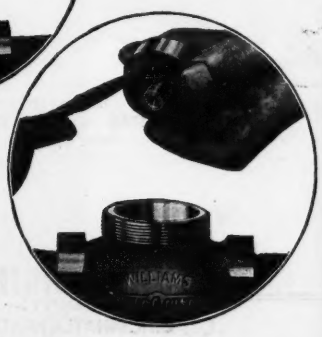
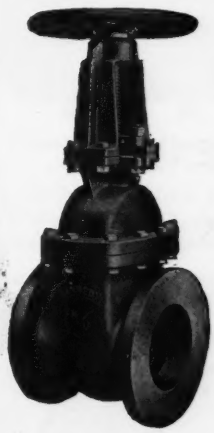




Dense without being brittle—tough, yet resilient, Vulcodisc will not swell, warp or soften—in fact, its absorption is less than 1 per cent. . . That is why an old Vulcodisc comes out of the disc Holder as easily as a new one goes in. No need for hammer and chisel to cut the disc out in pieces—distorting and disfiguring the Holder.
Write for descriptive bulletin.

THE D. T. WILLIAMS VALVE CO.
Cincinnati, Ohio

KENNEDY
VALVES-PIPE FITTINGS-FIRE HYDRANTS



WHEN you close a Kennedy Valve, you will find ample leverage on the handwheel, smooth positive operation and tight closure without strain. When the valve is to be opened again, you will find instant release of the operating mechanism at the first turn of the wheel and free easy motion.

Kennedy Valves are built to work effectively and dependably whether they are operated several times a day or infrequently. Each type is designed and tested to withstand far more than rated pressure and their ample margin of strength also protects against pipe strains and water hammer.

Kennedy Valve types include iron body and bronze gate, globe, angle and check valves for a wide range of pressures. They are obtainable through your local dealer, who can also supply you with Kennedy Cast Iron Flanged Fittings and Flanges, and Kennedy Malleable Iron and Brass Screwed Fittings.

THE KENNEDY VALVE MFG. CO.
Elmira, N. Y.
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STANDARDIZE ON LUNKENHEIMER

at the New York Power Show

A COMPLETE SERIES

LUNKENHEIMER

STEEL VALVES

150 to 1500 lb. SP

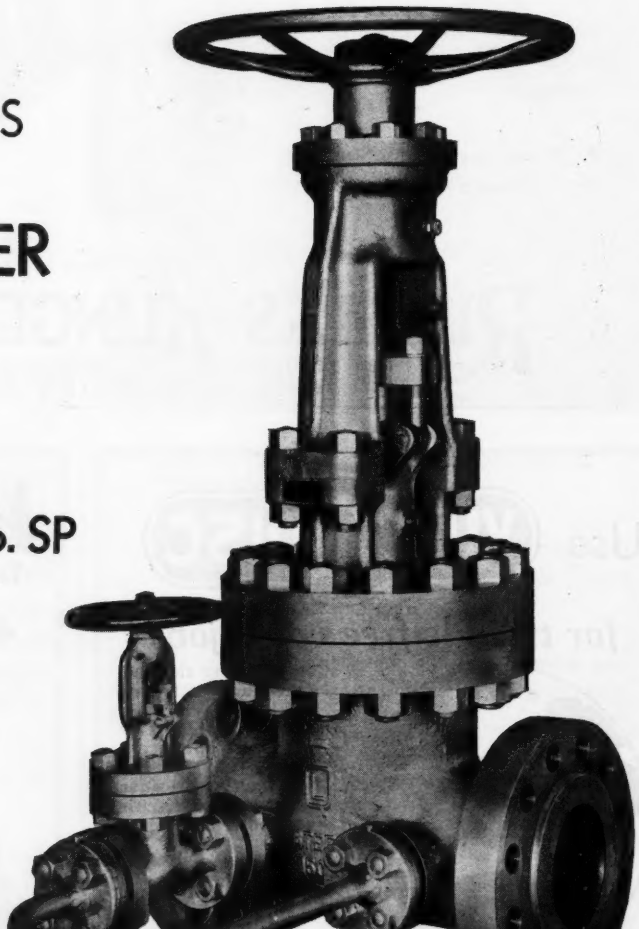
GATE

GLOBE

CHECK

NON-RETURN

BLOW-OFF



6" Fig. 1651
1500 lb. SP
STEEL GATE VALVE
With By-Pass

VISIT BOOTH No. 24

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
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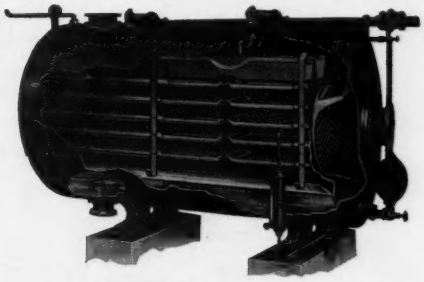
End *boiler corrosion* this easy Hoppes Way



Hoppes Class R, Type A Feedwater Heater.

Hoppes Steam Separators, Cast Iron Type. Sizes 1 to 9 in.

Hoppes Deaerating Feed Water Heaters will end corrosion and assure better steaming by furnishing your boilers hot soft water, free from dissolved air and other gases. . . .

Deaeration may be accomplished effectively and at low cost by the use of exhaust steam alone, or by the use of reboiler coil where insufficient exhaust steam is available to produce 212 deg. water. . . . Write for Catalog No. 90 telling all about Hoppes Heaters, Separators, V-Notch Meters and other Specialties.

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70 Larch St., Springfield, Ohio

HOPPES SPECIALTIES

5 BIG ADVANTAGES *check them!*

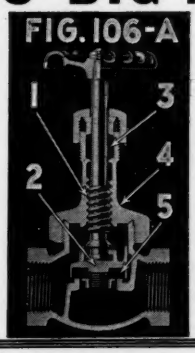
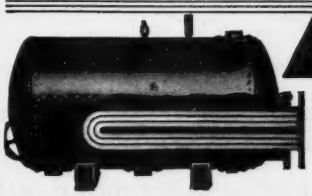


Fig. 106-A Jenkins Standard Bronze Globe Valve has: (1) More spindle threads in contact with bonnet; (2) Slip-on stay-on disc holder; (3) Extra-deep stuffing box holds more packing; (4) One-piece screw-over bonnet for strength; (5) Jenkins renewable composition disc. Same advantages in angle, cross and check patterns, screwed or flanged. Ask your suppy house or write for Form 142. JENKINS BROS., 80 White St., New York, Boston, Bridgeport, Philadelphia, Chicago.

JENKINS VALVES
Since 1864

NATIONAL HOT WATER HEATERS



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Manufacturers of Instantaneous, Feed Water, Fuel Oil and Storage Heaters, Coils, Pipe and Tube.

THE NATIONAL PIPE BENDING CO., Inc. 1883
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S-K PIPING

SHAW-KENDALL ENGINEERING CO.

Toledo, Ohio

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- Radial Brick Chimneys
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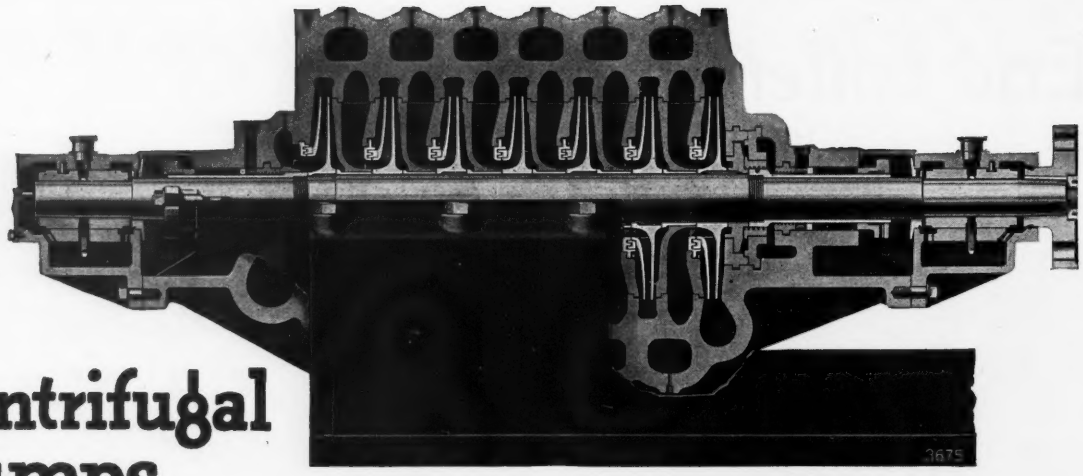


Centrifugal Pumps *for* HIGH PRESSURES

THE outstanding success of DE LAVAL centrifugal pumps for high pressures is due to a number of special features, one of the most valuable being:

1—The labyrinth wearing rings. These permit large radial clearance, thereby avoiding chance of seizure and rapid wear, while, at the same time, reducing leakage to a minimum. This joint between impeller and casing is where the greatest wear occurs in a centrifugal pump, and such wear affects the efficiency materially. De Laval labyrinth rings wear much less rapidly than do flat rings and can readily be renewed.

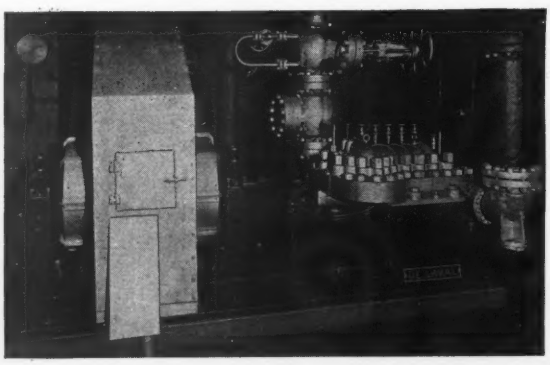
Other distinguishing features are:

2—Solid diaphragms, which prevent blowing out of gaskets and interstage casing leakage,

3—A hydraulic balancing system, which neutralizes axial thrust perfectly, and

4—For high suction pressures and high temperature liquids (as in boiler feeding), a system of **labyrinth rings for breaking down the suction pressure,** with the use of cool sealing liquid, so that high pressures and temperatures do not reach the stuffing box packings.

Ask for Catalog B-5.



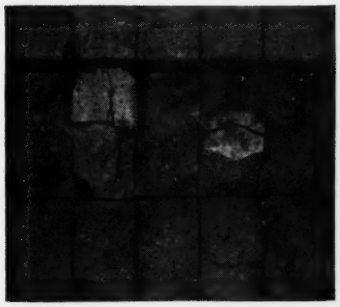
Six-stage pump delivering 800 g.p.m. against 1600 lb. discharge pressure at 3500 r.p.m.

De Laval Steam Turbine Co.
Trenton, New Jersey

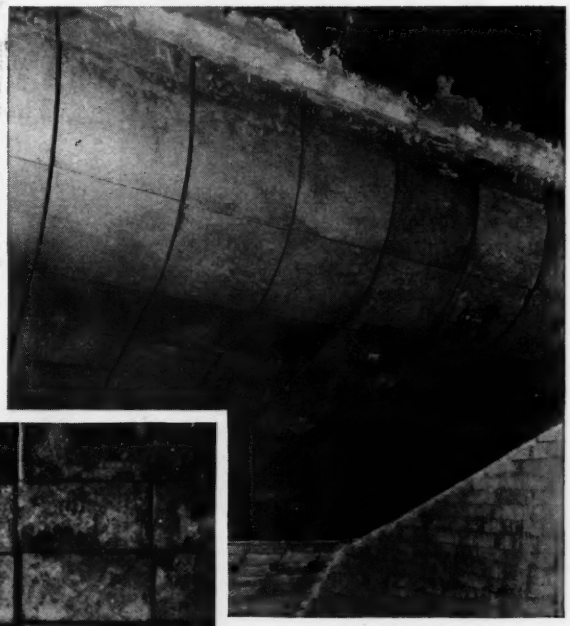
3139

THE CARBORUNDUM SYSTEM OF VENEERED SUSPENDED ARCHES SOLVES a PROBLEM

REG. U. S. PAT. OFF.



Unprotected arch in pre-heat zone in same installation after 150 days of operation at only 1700° F. Note spalling even under these conditions—1050° F. lower temperature and less sudden temperature changes.



Left, "Carbofrax" Veneered Arch after 150 days in hot zone at 2750° F. under conditions causing failure of other arches in 5 to 9 days.

MANY suspended arch installations are subjected to high temperatures, temperature changes, and localized flame erosion. Under such conditions the life of fire clay arch blocks is decidedly short.

In the Carborundum system, specially designed blocks of "Carbofrax," the Carborundum Brand Silicon Carbide Refractory are used.

They are applied as a veneer to the fire clay arches, forming a protective facing which is hung from the COOL OR OUTER SIDE of the arch—not from the hot side where failure of the fire clay arch would destroy the support for the protective veneer.

Many installations of this improved system show these advantages:

1—Complete protection of the hot face of the fire clay arch from flame impingement and spalling.
2—Protection of the joints between blocks.
3—Reduction in leakage or infiltration.
4—Accessible supporting means for the veneer blocks.
5—Long life of veneer blocks and easy means of replacement without disturbance of main arch.

The illustration, upper right, shows a "Carbofrax" veneered arch in a 650 B & W Sterling type boiler equipped with forced draft, chain grate stoker, operating at an average rating of 150%—maximum of 250%—burning Illinois coal. It is giving splendid service—no spalling—no softening.

"Carbofrax" Veneer can be applied to practically all types of suspended arches without change in basic method of suspension.

Tune in
THE CARBORUNDUM BAND
Saturdays at 9.30 E. S. T.
Columbia Chain

A SPECIALLY PREPARED BULLETIN WILL GIVE YOU COMPLETE ENGINEERING DETAILS

THE CARBORUNDUM COMPANY, *(Refractory Division)* PERTH AMBOY, N. J.

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(CARBORUNDUM AND CARBOFRAX ARE REGISTERED TRADE MARKS OF THE CARBORUNDUM COMPANY)

Why Do Leading Public Utilities Companies and Industrial Companies Specify

KENNEDY PULVERIZED FUEL SYSTEM?

The Answer Is—SIMPLICITY
RELIABILITY
DURABILITY
LOW OPERATING COSTS

What is the ratio of your steam cost to that of your finished product? There is a substantial saving possible by the use of the KENNEDY SYSTEM.

The KENNEDY PULVERIZED FUEL SYSTEM excels on all grades of fuels, enabling you to produce steam at a cost far below that obtainable with other systems.

THE PULVERIZER WITH THE TROUBLES LEFT OUT

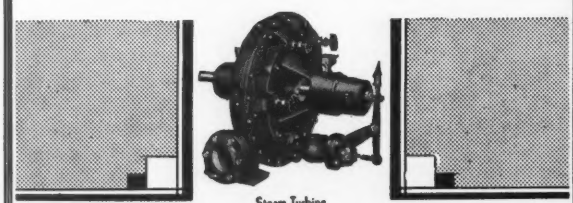
Bulletin 12-B will be sent upon request

Kennedy-Van Saun Mfg. & Eng. Corp.,
No. 2 Park Avenue, New York City

BRANCH OFFICES:—Chicago, 120 South LaSalle St. Birmingham, Ala., Comer Building. Los Angeles, Calif., 414 South Spring St. London, England, Bush House. Paris, France, 40 Rue des Mathurins. Johannesburg, S. Africa, 73 Cullinan Bldg. Canadian Agents: Canadian Fairbanks-Morse Co., 980 Antoine St., Montreal, Que. Cuban Agents: Gerard Jansen y Cia., Compostela, 43 Havana, Cuba. Walkers Limited, Maryborough, Queensland, Australia.

WIDELY USED

Carling Steam Turbines are being used increasingly to provide economical drives for pumps, fans, compressors and similar units. Write us today for further information. . . . . .



Carling Turbine Blower Co.
Worcester, Mass.

FIND OUT FOR YOURSELF
HOW YOU CAN
— CUT POWER COSTS —
STOWE STOKERS
with *Compensated Feed*

Will Burn the Cheapest Coal in Your Locality and Give the Lowest Steam Cost

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Motor—or Turbine—Driven

for making
MORE STEAM
MORE QUICKLY
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in boilers
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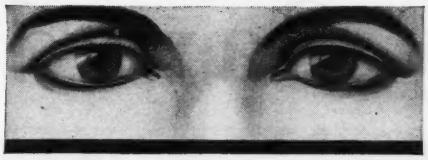
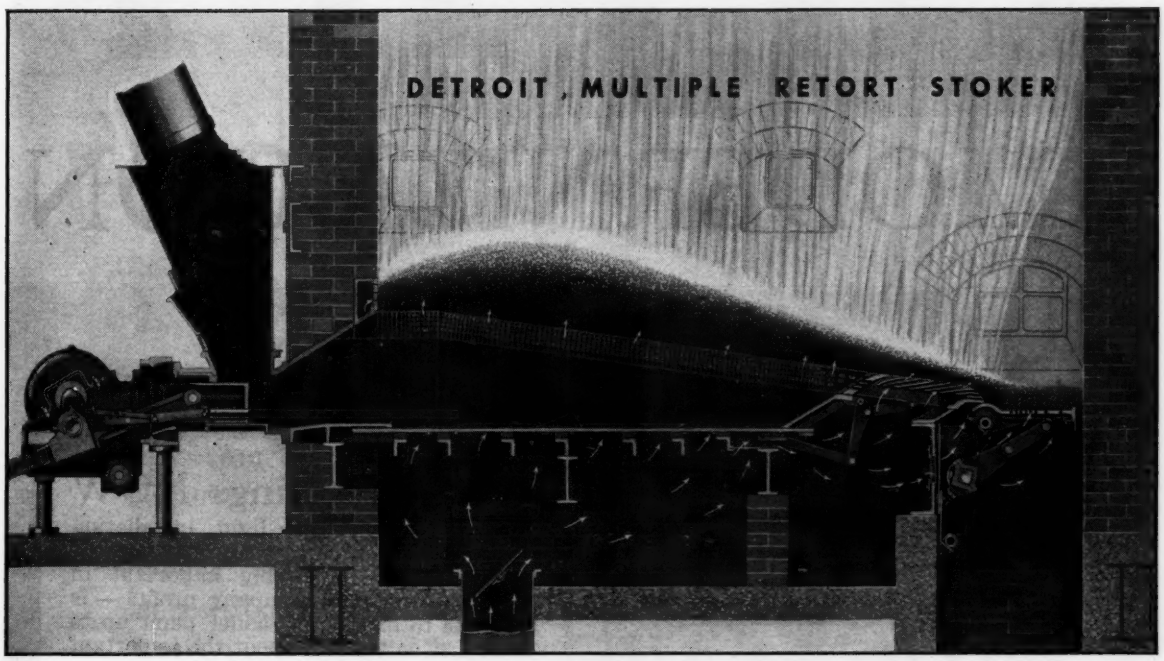


See It at the Power Show (Booth 73 MAIN FLOOR)



The Latest Development in the Economical Burning of Coal

In Booth 73 on the Main Floor at the New York Power Show, see the Detroit Multiple Retort Stoker —a stoker that is setting new standards in stoker performance.

Here are a few of its features: (1) Inclined fuel bed with complete underfeed action, (2) closely spaced square retorts have large capacity, (3) correct air distribution is insured by zoning of air and variation in tuyere openings, (4) extension moving grates, (5) individual adjustment of coal feed to each retort, and (6) adjustment of coal distribution in each retort is easily made while stoker is in operation.

If you do not attend the New York Power Show, get in touch with our nearest office for a copy of the new bulletin that completely illustrates and describes the Detroit Multiple Retort Stoker. Ask for Bulletin *124*.

DETROIT STOKER COMPANY

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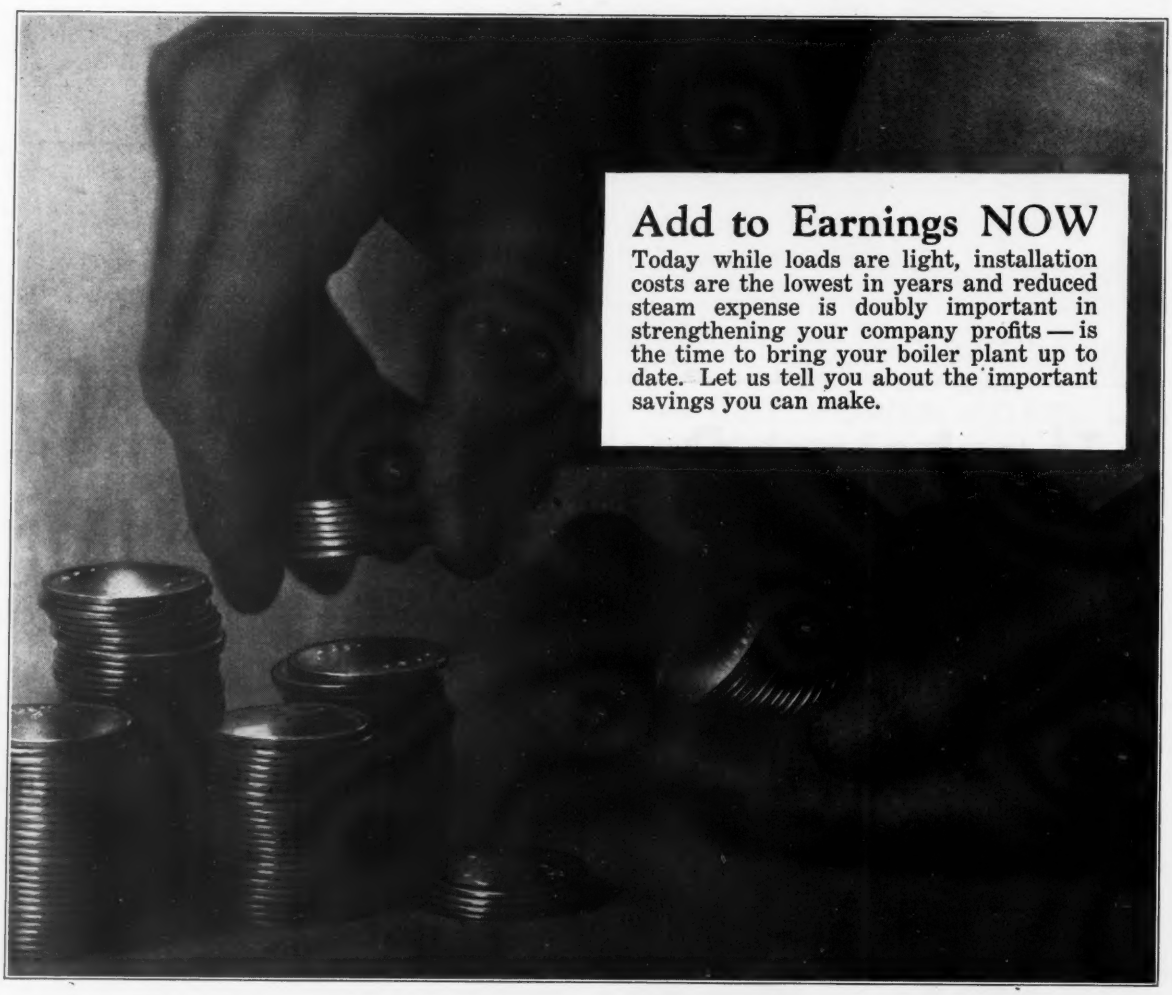

Add to Earnings NOW
Today while loads are light, installation costs are the lowest in years and reduced steam expense is doubly important in strengthening your company profits — is the time to bring your boiler plant up to date. Let us tell you about the important savings you can make.

AMERICAN

AMERICAN ENGINEERING COMPANY, 2408 ARAMINGO AVENUE, PHILADELPHIA, PA

Stoker

PROJECTS . . .

They Are Self-liquidating

"Revamping old boilers with Taylor Stokers saved $2000 a month for American Rolling Mills" . . . "reduced annual coal bill 40 per cent for Ball Brothers Company, Noblesville, Indiana plant . . . "saved 3,000 tons of coal a year and 33 1/3 per cent of power plant payroll for Champion International Company and permitted further savings by use of cheaper grades of fuel" . . . are typical reports from users of Taylor Stokers.

These highly efficient modern stokers show such tremendous steam-generating economies that they soon liquidate their initial cost, then continue to "say it with savings" month after month.

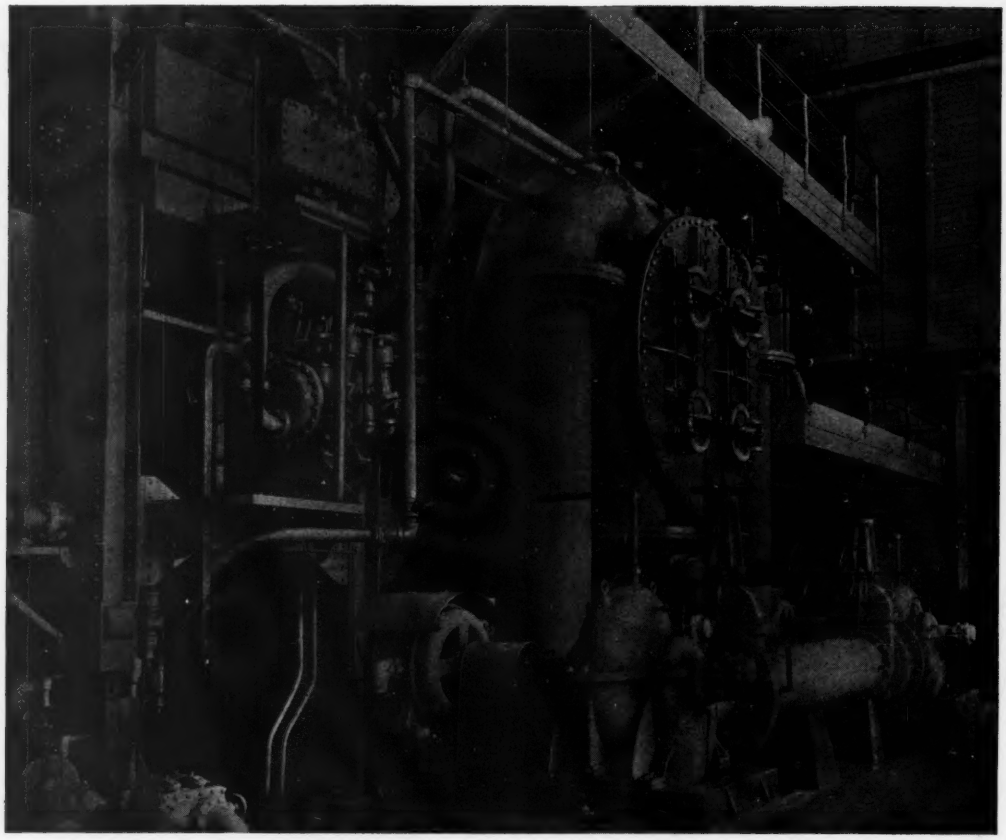
That is why many industrial plants and central stations are commonly able to finance Taylor Stoker Modernization Projects through easy short-term loans.

Now is the best time to prepare your plant for the upswing of business—to modernize old units or install new ones. A relatively small investment in Taylor Stokers will produce cheaper steam, reduce costs all along the line, improve your company's competitive position, increase your profits. Ask us to prove it.

ENGINEERING

IN CANADA; AFFILIATED ENGINEERING COMPANIES, LTD., MONTREAL, P. Q.

FOSTER WHEELER



Foster Wheeler condenser containing 9400 sq. ft. heating surface. Foster Wheeler accessories included with this condenser are 150 sq. ft. external air cooler, twin two-stage steam jet air pump, centrifugal circulating water pumps and centrifugal hotwell pumps.

PRODUCTS

The products of Foster Wheeler are built on a foundation of many years engineering experience in each field covered. All major equipment for power plants, excepting prime movers, may be designed, built and installed under a single contract with unit responsibility. Foster Wheeler is the pioneer in the manufacture or use of many of the products listed below.

Foster Wheeler Products:

For the Boiler Room

Complete steam generators
Air preheaters
Ash removal systems
Boilers
Burners
Coal feeders
Economizers
Expansion joints
Furnaces
Pulverizers
Pumps
Superheaters
Water walls

For the Turbine Room

Condensers
- Barometric
- Jet
- Surface

Condenser tubes
Cooling towers
Evaporators
Expansion joints
Feed water heaters
Heat exchangers
Steam jet air pumps
Steam reheaters
Water pumps

For Industrial Work

Brass and copper pipe
Coolers
Direct fired superheaters
Expansion joints
Heaters
Heat exchangers
Pumps
- Centrifugal
- Steam jet vacuum

Stills
Thermo compressors
Vacuum refrigeration units
Waste heat boilers

Firing aisle of modern industrial power plant showing five Foster Wheeler steam generating units of 500 hp. each. The Foster Wheeler equipment includes unit coal pulverizers, turbulent type burners, water cooled furnaces, radiant superheaters and extended surface economizers.

FOSTER WHEELER

SERVICE

The wide organization maintained by Foster Wheeler to assure excellent service is backed by several shops located at carefully selected centers. The list below gives the location of Foster Wheeler shops, sales and engineering offices. In addition to these there are numerous agents and representatives, both in the United States and abroad.

Foster Wheeler Organization:

General Offices: 165 Broadway, New York, N. Y.

Works: Carteret, N. J.: Dansville, N. Y.: Cleveland, Ohio.

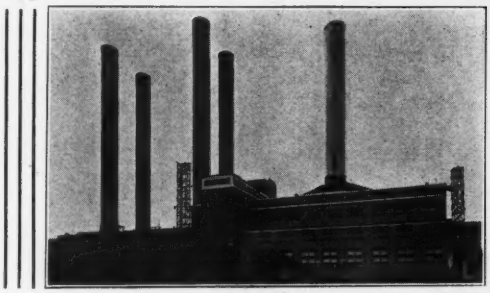
Sales and Engineering Offices and Representatives:

Atlanta	Candler Building	Honolulu, T. H.	P. O. Box 64
Boston	80 Federal Street	Kansas City	Board of Trade Building
Chicago	20 North Wacker Drive	Los Angeles	Consolidated Steel Corp.
Cincinnati	18 East 4th Street	New Orleans	American Bank Building
Cleveland	1170 Ivanhoe Road	Philadelphia	Packard Building
Dallas	Republic Bank Building	Pittsburgh	Oliver Building
Detroit	Dime Bank Building	San Francisco	Consolidated Steel Corp.
Denver	1720 California Street	Tulsa	712 Thompson Building

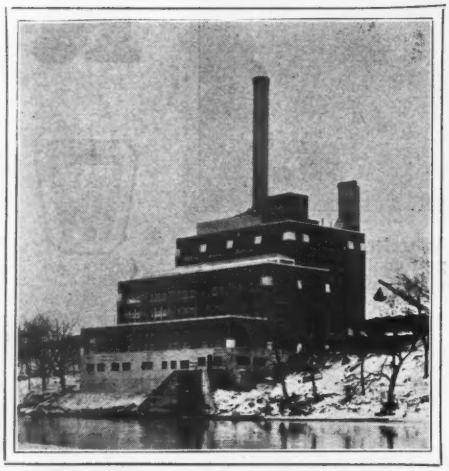
Canada—Foster Wheeler Limited—Montreal, Toronto, St. Catharines.
England—Foster Wheeler Limited—Aldwych House, W. C. 2, London.
France—Societe Anonyme Foster Wheeler—42 Rue de Clichy, Paris.

SPRINGFIELD BOILERS & WATER WALLS

SECTIONAL —— ALL STEEL



3-250,000 lb. Springfield Units Installed



2-150,000 lb. Springfield Units Installed

One of the largest engineering companies in the world has installed SPRINGFIELD BOILERS and WATER WALLS in FOUR of their principal generating stations at FOUR different times. (Name on request.)

Many other large power users have repeatedly ordered SPRINGFIELD Units.

THERE ARE REAL REASONS — INVESTIGATE —

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SPRINGFIELD UNITS ARE BUILT IN ALL SIZES AND FOR ALL PRESSURES

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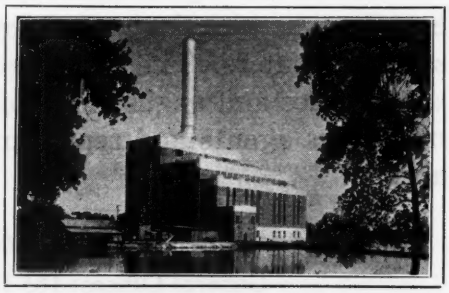

3-180,000 lb. Springfield Units Installed

REPEAT ORDERS CONSTITUTE THE LARGEST PART OF OUR BUSINESS

SPRINGFIELD BOILER CO.

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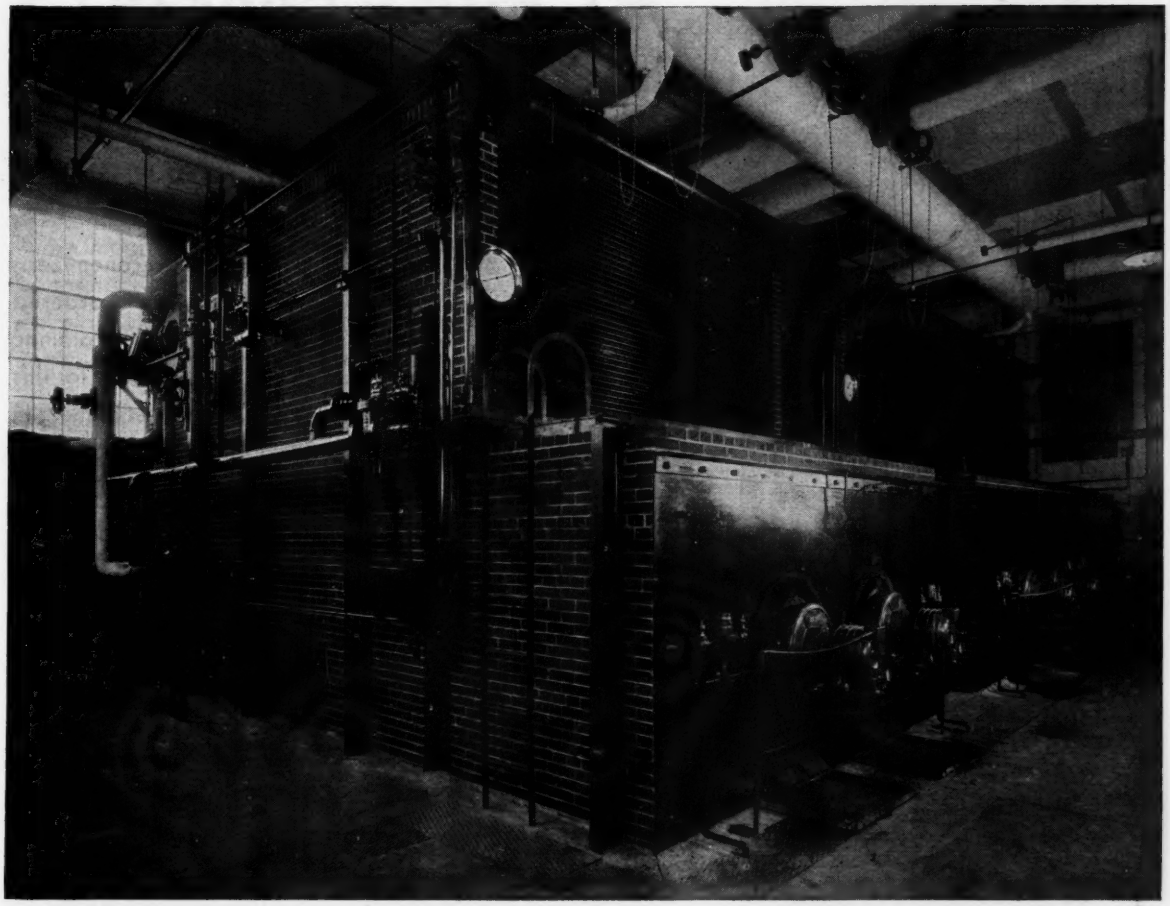

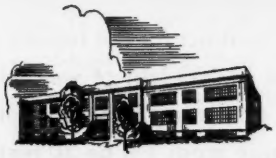

FEDERAL, State, County and Municipal Departments have installed many Edge Moor Boilers in Government and Public Buildings—in the power plants of many agencies for public service.

Public Works are always under public scrutiny. Never have Edge Moor Boilers failed to demonstrate the good judgment of the engineers and public officials who have selected them—no doubt a major reason for an ever-growing appreciation of the dependability of these steam generators.

Representative installations of Edge Moor Boilers in public works include: five U. S. Navy Yards; the U. S. Soldiers Home at Washington; pumping stations in the Cities of Chicago, Philadelphia, Atlanta, Minneapolis, Wilmington, Baltimore and others; various municipally-owned electric and gas utilities; many municipal, county and state hospitals, institutions and schools.

Illustrated above is the boiler room of the Lower Merion Township High School at Ardmore, Pa. (Harry J. Eggley, Engineer)—a typical modern installation of Edge Moor heating boilers, particularly well adapted to this type of service. These three cross-drum type units of 311 horse-power each, were built for 160 lbs. operating pressure. They are equipped with May Oil Burners and Diamond "Air Puff" type soot cleaners.

Many other types of Edge Moor Boilers are made to serve the widely varied needs of American Business and Industry. What are your requirements?

EDGE MOOR BOILERS

EDGE MOOR IRON CO.
EDGE MOOR, DELAWARE
Established 1868

New York Chicago Boston Charlotte St. Paul Los Angeles
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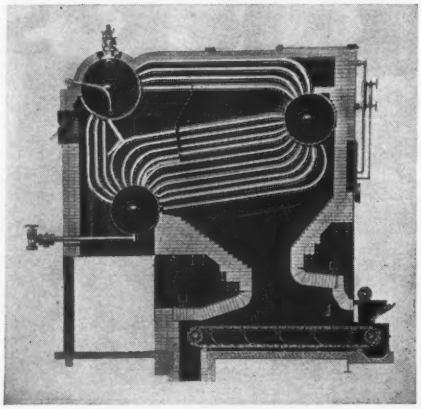
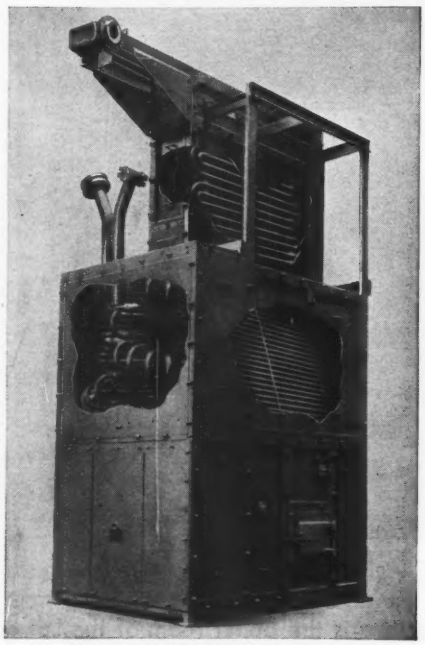
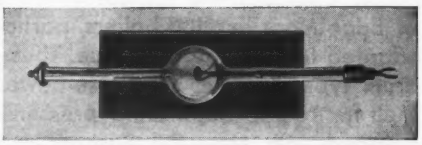


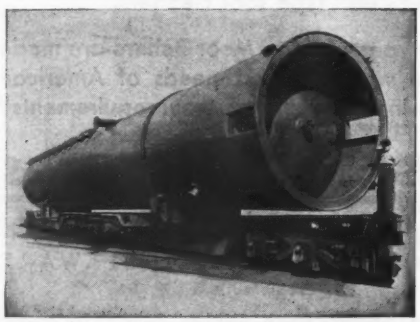
Total small-boiler heating surface passes one-million-square-foot mark.



Babcock & Wilcox Diphenyl Boiler enters successful service.



First 300,000 volt X-ray equipment installed.



One of the world's largest Bubble Towers delivered.

ACHIEVEMENTS *of* 1932

THE Babcock & Wilcox Boilers, Superheaters, Economizers, Air Heaters, and Bailey Water-Cooled Furnaces ordered for the new Washington, D. C., Station of The Potomac Electric Power Company constitute the largest order for this type of equipment placed this year. The latest refinement in B & W Light-Weight Insulated Casing is one of many features of this installation of modern power-plant equipment.

From coast to coast, installations of small moderately-priced Type H Stirling Boilers, introduced in 1929, now have a total of more than 1,000,000 square feet of heating surface.

To date, orders for more than 455 boiler drums with welded seams provide convincing evidence of Babcock & Wilcox leadership in fusion-welding.

The scope of the Babcock & Wilcox Fusion-Welding Technique has been materially extended by the installation of the first 300,000 volt X-ray equipment and the construction of one of the largest stress-relieving furnaces at the company's Barberton, Ohio, Works.

The Company was awarded the contract for the fabrication and installation of more than 14,000 feet of welded plate-steel pipes for the hydraulic-power and flood-control tunnels at Hoover Dam. Most of these pipes will be 30 feet in diameter, up to 2⅞ inches in thickness and will weigh 150 tons per erection-section . . . the largest ever constructed.

A new wall structure developed by the Company for water-cooled furnaces demonstrated its ability to withstand the severe operating conditions encountered in central station service. This new Bailey Stud Tube Wall is a worthy companion of the Bailey Block-Covered Water-Cooled Furnace.

A new high-capacity record was established by a Babcock & Wilcox Type B Pulverizer by pulverizing over 50 tons of coal per hour at the Kip's Bay Station of the New York Steam Corporation.

Another Babcock & Wilcox Pulverizer reduced the power consumption for raw-material grinding by 47 per cent in regular cement-plant operation.

One of the world's largest Bubble Towers was erected in 1932 at Bayonne, New Jersey. This tower, built by Babcock & Wilcox, is 93 feet high, and weighs more than 325,000 pounds.

An important installation of a mercury boiler and mercury-vapor heat-transfer equipment was made in a large chemical plant . . . equipment containing many new and advantageous features of design and operation.

At Marcus Hook, New Jersey, the use of diphenyl as a heat-transfer medium in a special boiler built by this organization met with marked success in one of the country's largest industrial establishments. The Company is also prepared to build boilers for use with diphenyl oxide and Dowtherm as heat-transfer mediums.

The greatest advance in sulphite cooking in recent years was made in the Kimberly Mill of the Kimberly-Clark Corporation with equipment built by Babcock & Wilcox. This digester control system, now marketed by The Babcock & Wilcox Company, improves the quality of the pulp, raises the pulp yield, increases the output of the digester, and reduces the consumption of sulphur, lime, and steam.

Unprecedented savings of 48.5 per cent in fuel per cycle and 89 per cent in the time required to bring a high-speed heat-treating furnace to operating temperature were secured through the installation of B & W No. 80 Insulating Firebrick . . . savings duplicated or exceeded in many other installations.

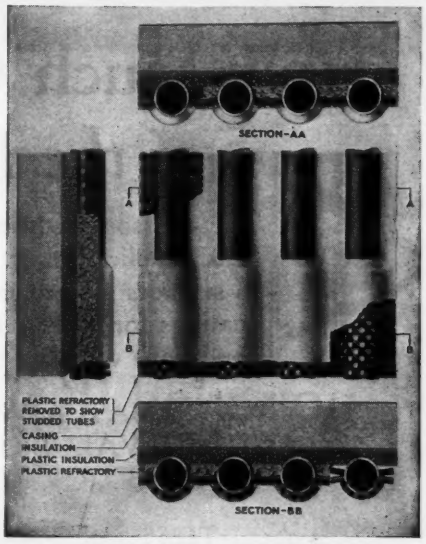
The majority of ships launched in this country in 1932 contain Babcock & Wilcox Marine Equipment . . . definite assurance of economical and thoroughly dependable service.

These achievements of The Babcock & Wilcox Company in 1932 reflect the company's progressiveness and continuing leadership.

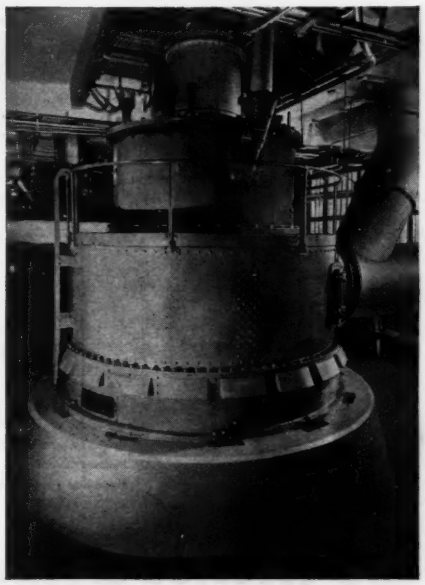
The Babcock & Wilcox Company . . . 85 Liberty St. . . . N. Y.

BABCOCK & WILCOX

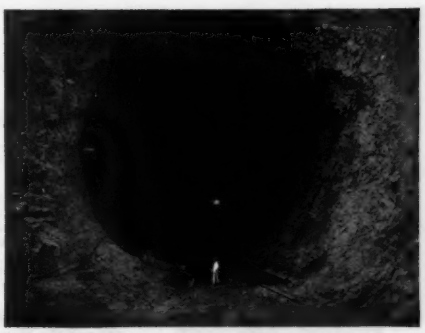
G-27-T



Stud Tubes, a new water-cooled furnace-wall structure, developed.



Babcock & Wilcox Pulverizer sets new capacity record.



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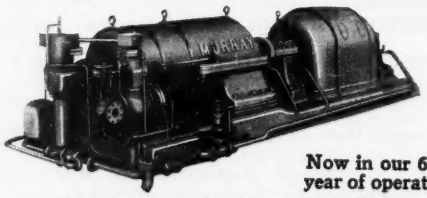

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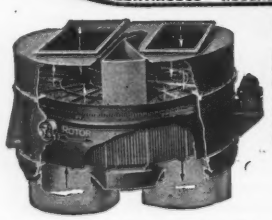

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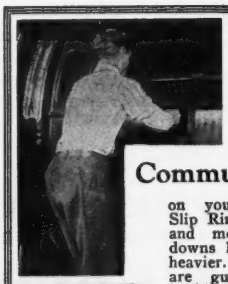

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When

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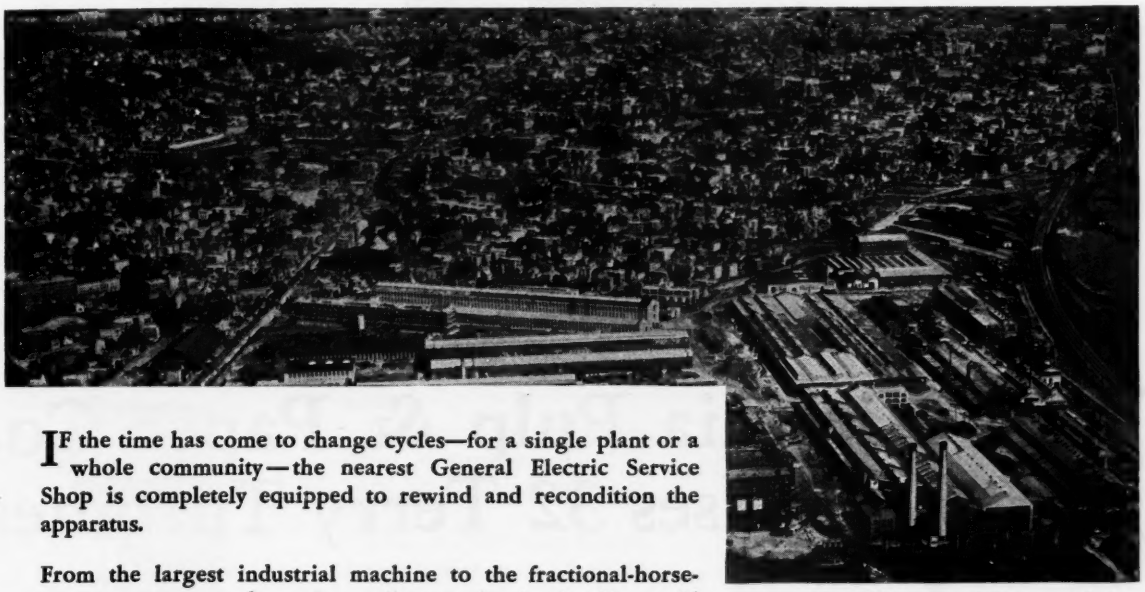

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GENERAL ELECTRIC

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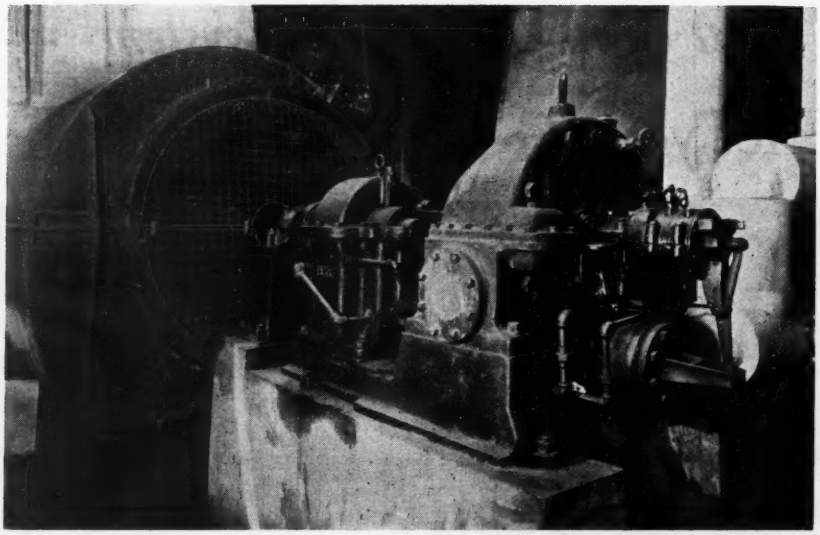

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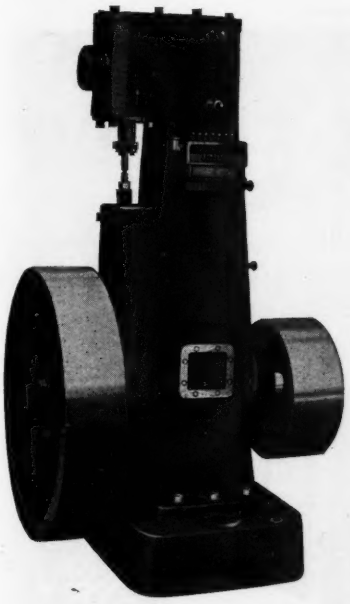

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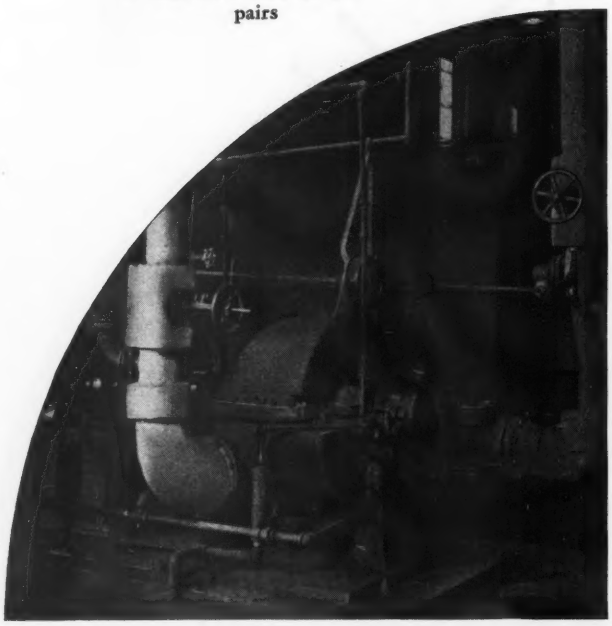
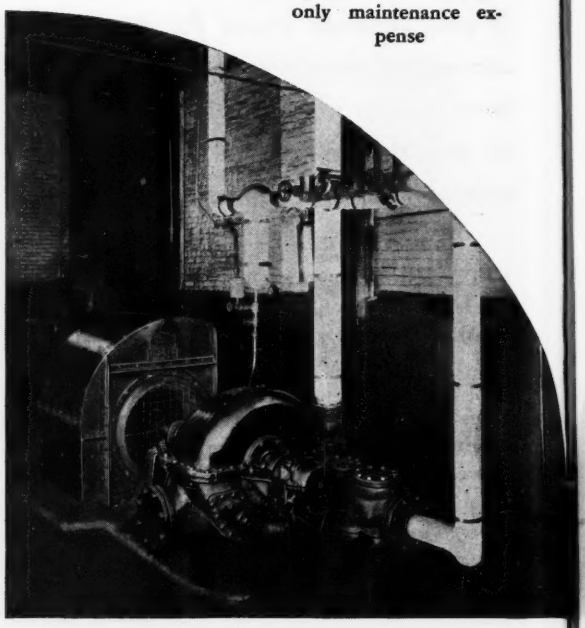
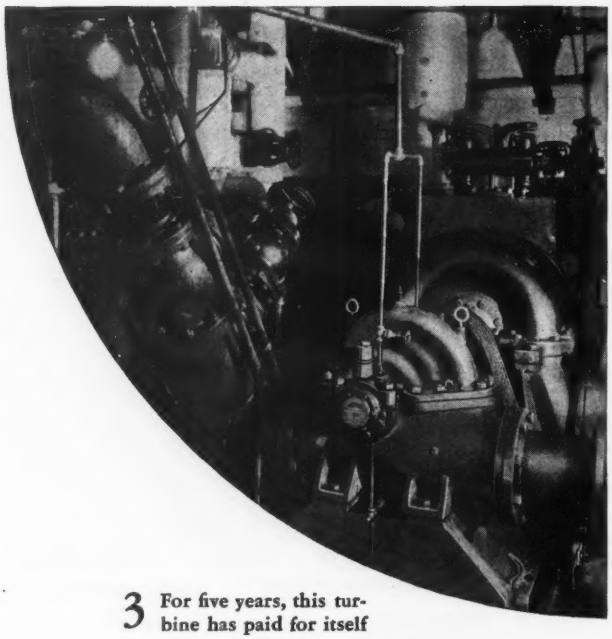
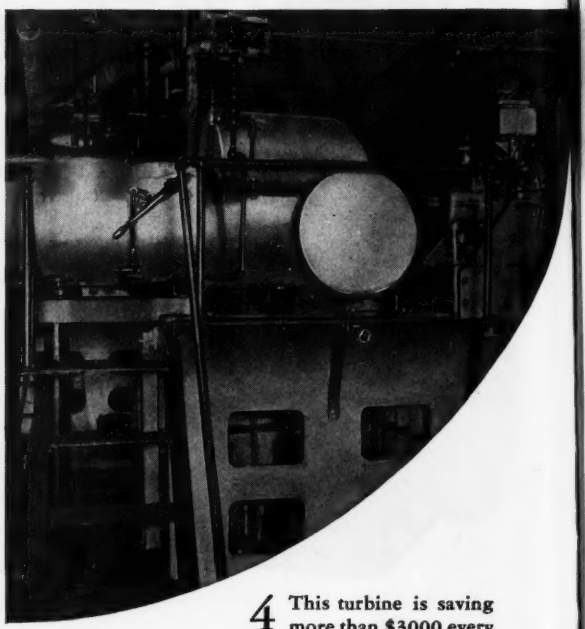


2 Three years' continuous operation and oil the only maintenance expense





3 For five years, this turbine has paid for itself every year



4 This turbine is saving more than $3000 every year

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